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INVESTIGATIONS MADE WITH THE KONIMETER TO ASCERTAIN THE AMOUNT OF DUST PRODUCED IN DRILLING HOLES BY MEANS OF DRY JACK HAMMER MACHINES.

By H. E. Barrett (Member).

In this paper by "dry jack hammer" is meant a hammer type machine with air only passing through the hollow steel to the bottom of the hole being drilled, the water to allay dust being led into the mouth of the hole by means of a separate hose pipe, as required by the regulations.

In referring to results as satisfactory or unsatisfactory I have adopted the standard suggested by the Miners' Phthisis Prevention Committee; namely, that dust in excess of 300 particles per cc. should be considered unsatisfactory.

Doubt as to whether the dry jack hammers produced an injurious amount of dust first arose in connection with sinking shafts. In order to ascertain the actual conditions at the bottom of shafts being sunk along the Reef by means of such machines, Mr. Atkin, of the Mines Department, took a series of samples in nine shafts. The average result was 1,082 particles per cc., the lowest being 450 particles per cc. and the highest 1,800. The samples were taken about level with the drillers' mouths. Even in cases where the holes were being drilled under water unsatisfactory results were obtained. It was then deemed advisable that Inspectors of Mines should take a series of samples in stopes on different mines under ordinary working conditions, and I was deputed to do that work in the Johannesburg and Germiston Districts.

I visited seven mines with the following results, each sample determination being the average of counts of three spots.

(a) Machines using solid starters and entirely hollow star bits, *i.e.*, drills with central hole extending to the cutting edges.

Samples taken 2 ft. from holes on leeward side—average for 65 samples = 724 particles per cc.

Samples taken at drillers' mouths—Average for 74 samples=667 particles per cc.

(b) Machines using solid starters and chisel bits with air outlet placed from 1 in. to 3 in. above cutting edge and at right angles to drill.

Samples taken 2 ft. from holes on leeward side—average for 11 samples = 544 particles per cc.

Samples taken at drillers' mouths—average for 15 samples=428 particles per cc.

(c) Machines using solid starters and chisel bits with air outlet placed from 1 in. to 3 in. above cutting edge and pointing towards cutting edge.

Samples taken 2 ft. from holes on leeward side—average for 27 samples = 391 particles per cc.

Samples taken at drillers' mouths—average for 23 samples = 275 particles per cc.

The above samples were taken at holes varying in depth from being collared to 48 in., and at the time notes were made of the conditions prevailing in the stopes and under which the holes were drilled. The dust was invariably found to be exceedingly fine, there being rarely if ever above 5% of particles above 5 microns in size.

The variations in ventilation, number of machines at work, eddying of air currents due to the exhaust from the machines and other conditions made it impossible to deduce any general conclusions as to the conditions under which more or less dust was formed by the machines; except that it appeared probable that chisel bits made less dust than star bits, and that less was made with an air outlet directed towards the cutting edge than with one at right angles to its length.

To throw more light on this matter tests Nos. 1 and 2 were carried out under similar conditions in a stope. Two down holes were drilled with the same machine and water appliances, one with (a) bits and the other (c) bits. Three samples, each of three spots, were taken 2 ft. from the collars of the holes being drilled on the leeward side, at intervals of every 4 in. drilled.

The average results obtained were:—
with (a) bits 602 particles per cc.
with (c) bits 509 particles per cc.

It will be seen that the difference is not great, and that both results are unsatisfactory.

To investigate further the influence of differently shaped bits with differently placed air outlets on the dust produced, and at the same time, if possible, to obtain graphs showing how the dust varied with the depth of hole drilled, tests 6, 7 and 8 were carried out in a winze in which the air current was upward.

The same machine, natives and water appliances were used to drill one down hole 44 in. deep with each of the following kinds of bits:—

(a) Solid starter and entirely hollow star bits.

(c) Solid starter and chisel bits with air outlet $1\frac{3}{4}$ in. above cutting edge and pointing towards cutting edge.

(d) Solid starter and hollow star bits with air outlet $1\frac{3}{4}$ in. above cutting edge and pointing towards cutting edge.

In order to obtain the dust contents of the atmosphere passing the machine, samples were taken before drilling in each hole.

Obviously, if it is wished to know how much dust is produced by a machine working in an air current, it is necessary to ascertain not only the number of particles of dust per cubic centimeter of air in the actual sample taken, but also the number of cubic centimeters of air which were polluted to that extent by the machine. In other words, it is necessary to take into account the quantity of air passing the machine.

With the idea of correcting the results for variation in the air current, anemometer readings were taken simultaneously with the dust samples, in an opening in a wooden doorway fixed near the top of the winze and 25 ft. above the holes being drilled. The dust samples were taken 18 ft. above the machines so as to avoid interference from the exhaust and compressed air leakage, and on the completion of each 4 in. drilled. Unfortunately it was found that the variations in velocity of the air current and in the amount of dust in the atmosphere before it reached the machine, were so frequent and great that it was impracticable to secure accurately comparable results.

The average results actually obtained for each hole were as follows:—

(a) Air passing machine—2,964 cub. ft. per min.

Average dust in air passing machine—200 particles per cc.

Average dust in air 18 ft. above machine—427 particles per cc.

(c) Air passing machine—3,570 cub. ft. per min.

Average dust in air passing machine—156 particles per cc.

Average dust in air 18 ft. above machine—352 particles per cc.

(d) Air passing machine—3,200 cub. ft. per min.

Average dust in air passing machine—170 particles per cc.

Average dust in air 18 ft. above machine—270 particles per cc.

With the same objects in view, but in order to maintain constant conditions, tests Nos. 10, 11 and 14 were carried out as follows:—

Two wooden ventilating doors made as air-tight as possible, but which still allowed a very slight drift of air, were fixed across a cross-cut in close proximity to a down-cast shaft, so as to form a chamber 53½ ft. long × 9 ft. wide × 7½ ft. high with capacity of 3,611 cub. ft.

In order to avoid the samples being contaminated by carbon particles from carbide lamps (which sometimes is the case in confined spaces, making accurate counts difficult) the chamber was lit by electricity.

The holes were drilled by an Ingersoll dry jack hammer machine, which was rigged up at approximately the centre of the chamber. Before drilling commenced the chamber was well wetted down, both doors were closed and three samples were taken of the atmosphere in the chamber at intervals of 13 ft. along its length, so as to obtain the initial dust contents. Drilling was then commenced with a starter, the air pressure at the machine, time taken to drill and depth drilled being carefully noted. As soon as drilling ceased, six samples were taken at the same intervals of 13 ft., the first three while travelling from the intake side of the chamber and the other three returning, after which both doors were opened and the dust laden atmosphere blown out by the natural ventilating current. This process was repeated for each bit used. Water was continuously applied to the mouths of the holes drilled, in a gentle stream by means of a ½ in. hose pipe running full bore, one of the two natives with the machine applying it under my supervision.

The results obtained are attached in tabular form, and the corresponding graphs appear on the chart. An attempt to make similar tests with chisel bits failed, as they broke up on account of the hardness of the rock.

Tests 10, 11 and 14 confirm the high results obtained from samples taken in stopes under ordinary working conditions, and also show that after a comparatively shallow depth has been reached, the dust produced increases very rapidly. During use of the fourth jumper in each test, the air in the chamber became visibly hazy especially on the leeward side of the machine, and in test No. 10 in particular a cloud of dust was noticed to issue continuously from the hole in spite of water being carefully applied.

It appears from the tests that while differently shaped bits having differently placed air outlets influence the dust produced to a certain extent, the difference is not sufficient to make the drill with any bit satisfactory from a health point of view.

Though in the absence of sufficient information with regard to the wet jack hammer, in which water as well as air is passed through the hollow steel, I have limited my paper to the results given by the dry machine, it may be of some interest if I give for comparison those results for the wet machine which I have available. I must however point out that they are perhaps unduly favourable to the wet machine under average conditions, as they were made with machines working under high water pressure, and with single cocks governing both air and water supplies. The machines were equipped with short internal water tubes.

Samples taken in stopes under ordinary working conditions with entirely hollow star bits, including the starter, gave the following results:—

2 ft. from hole on leeward side—average of six samples=152 particles per cc.

At drillers' mouths—average of 18 samples =107 particles per cc.

Tests 12 and 13, of which the results are attached, and of which the graphs are included in the chart, were carried out in the chamber under similar conditions to tests 10, 11 and 14. Actually the same machine was used with fittings converting it to a waterfed machine. The water supply, from a surface dam, was clear, and while drilling a medium fog was produced in the chamber, and a coarse spray of water issued from the machine chuck.

Tests 6 to 14 were made in the Ferreira Deep Gold Mine, and I have to acknowledge the facilities and assistance given by the management and officials of that mine.

TEST No. 10.

Machine used: Ingersoll Dry Jack Hammer. Rigged.
Starter: Solid Star bit.
Dip of hole: 24°.
Other drills: Entirely hollow Star bits.
Rock drilled into: Hard quartzite.

Drill used.	Depth drilled in inches	Air pressure lbs. per sq. inch.	Time drilling in minutes.	Air samples particles per c.c.	Average.	Dust samples particles per c.c. u = micron.	Average.	Corrected dust average nett dust produced
				60 2 + 5u 50 2 + 5u	55			
Solid Starter	6	50	4½			90 8 + 5u 100 16 + 5u 120 8 + 5u 128 2 + 5u 120 4 + 5u 100 4 + 5u	110	55
				80 4 + 5u 40 none + 5u	60			
Second	10	73	3¾			240 8 + 5u 300 8 + 5u 380 4 + 5u 400 4 + 5u 260 4 + 5u 240 4 + 5u	303	243
				50 2 + 5u 40 8 + 5u 50 2 + 5u	47			
Third	10	60	3			560 4 + 5u 500 8 + 5u 950 8 + 5u 1,000 8 + 5u 560 4 + 5u 600 4 + 5u	695	648
				70 4 + 5u 64 4 + 5u 50 2 + 5u	61			
Fourth	10	68	3			950 8 + 5u 1,100 8 + 5u 1,200 16 + 5u 1,100 24 + 5u 700 8 + 5u 800 4 + 5u	975	914
	36		14¼		56		521	465

TEST No. 11.

Machine used: Same as in Test 10. Rigged.
Starter: Solid Star bit.
Air outlet 1¾ in. above cutting edges and looking towards cutting edges.
Other drills: Star bits—hole at side.
Dip of hole: 23°.
Rock drilled into: Hard quartzite.

Drill used.	Depth drilled in inches.	Air pressure lbs. per sq. inch.	Time drilling in minutes.	Air Samples particles per c.c.	Average	Dust samples particles per c.c. u = micron.	Average.	Corrected dust average nett dust produced parts. per c.c.
				80 70 80	77			
Solid Starter	6	63	3½			110 8+5u 120 4+5u 100 4+5u 140 8+5u 130 4+5u 140 4+5u	123	46
				60 2+5u 70 2+5u 50	60			
Second	10	73	4¾			108 2+5u 140 2+5u 180 2+5u 240 8+5u 200 4+5u 180 2+5u	174	114
				50 2+5u 60 4+5u	55			
Third	10	60	5¼			80 2+5u 100 2+5u 120 2+5u 170 4+5u 150 4+5u 100 4+5u	120	65
				60 4+5u 60 2+5u 80 4+5u	67			
Fourth	10	65	3			800 8+5u 900 8+5u 1200 16+5u 1000 8+5u 700 8+5u 900 16+5u	917	850
	36		16½		65		353	269

TEST No. 14.

Machine used: Ingersoll Dry Jack Hammer. Rigged.
Starter: Solid Star bit.
Other drills: Star bits with air outlet $1\frac{3}{4}$ in. above cutting edges and looking towards cutting edges.
Dip of hole: 30°.
Rock drilled into: Hard quartzite.

Drill used.	Depth drilled in inches	Air pressure lbs. per sq. inch.	Time drilling in minutes.	Air samples particles per c.c.	Average.	Dust samples particles per c.c. u = micron.	Average.	Corrected dust average nett dust produced, parts per c.c.
				66 4 + 5u 70 4 + 5u 80 4 + 5u	72			
Starter	6	68	2			100 2 + 5u 160 4 + 5u 220 4 + 5u 160 4 × 5u 128 4 + 5u 150 4 + 5u	153	81
				50 2 + 5u 80 4 + 5u 50 2 + 5u	60			
Second	10	68	$3\frac{1}{2}$			180 2 + 5u 220 4 + 5u 320 4 + 5u 320 4 + 5u 300 4 + 5u 240 4 + 5u	263	2[illegible]3
				54 2 + 5u 80 2 + 5u 60 2 + 5u	65			
Third	10	68	$4\frac{1}{2}$			300 2 + 5u 360 2 + 5u 400 2 + 5u 440 2 + 5u 360 2 + 5u 300 2 + 5u	360	295
				80 4 + 5u 60 4 + 5u 60 4 + 5u	67			
Fourth	10	68	5			800 2 + 5u 800 2 + 5u 1,050 4 + 5u 1,100 2 + 5u 1,000 2 + 5u 800 2 + 5u	925	858
	36		15		66		425	359

TEST No. 12.

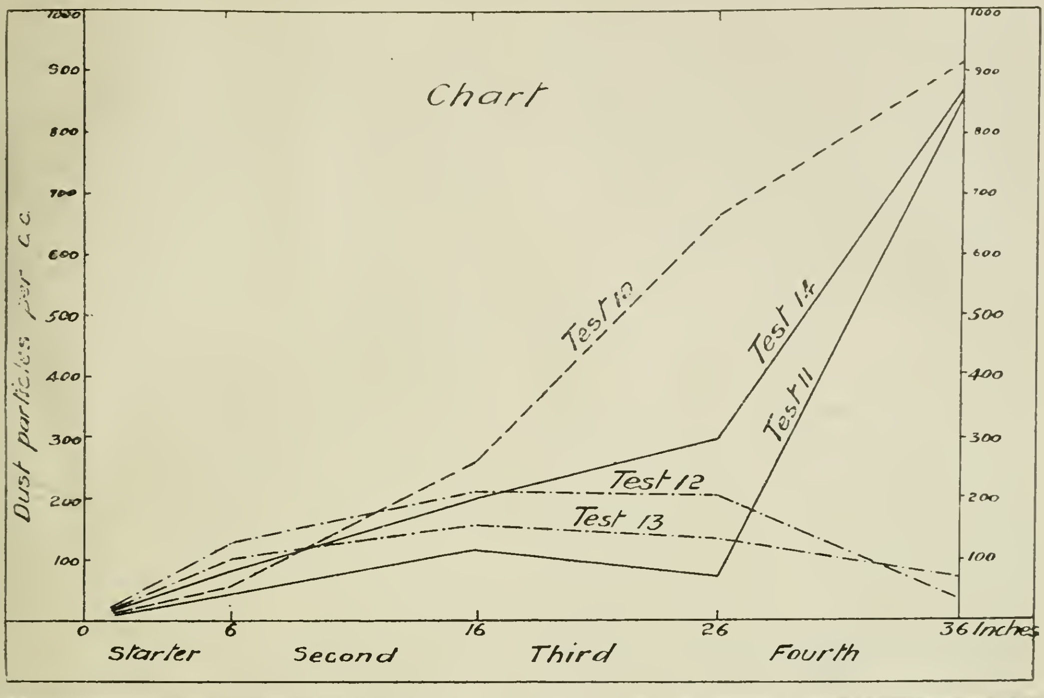
Machine used: Converted Ingersoll Axial Water-feed Jack Hammer. Rigged.
Starter: Entirely hollow Star bits.
Other drills: Entirely hollow Star bits.
Dip of hole: 27°.
Natives per machine: One.
Rock drilled into: Hard quartzite.
Length of water tube in machine=$12\frac{3}{8}$ in.
Internal diameter of water tube where water enters=$\frac{1}{8}$ in.
Internal diameter of water tube where water exits=1/16 in.
When drill in position in the chuck, end of tube was $2\frac{1}{2}$ in. from shank end of drill.

Drill used.	Depth drilled in inches.	Air pressure lbs. per sq inch.	Water press lbs per sq. inch.	Time drilling in minutes.	Air samples particles per c.c.	Average	Dust samples particles per c.c. u = micron.	Average.	Corrected dust average nett dust produced particles per c.c.
					40 2+5u 70 2+5u 50 2+5u	53			
Starter	6	68	96	3			160 4+5u 160 8+5u spoiled 220 2+5u 140 4+5u 200 4+5u	176	123
					36 2+5u 64 4+5u 60 2+5u	53			
Second	10	68	96	4			300 2+5u 270 2+5u 240 4+5u spoiled 240 4+5u	262	209
					30 2+5u 50 4+5u 40 2+5u	40			
Third	10	68	96	3			160 4+5u 200 2+5u 140 2+5u 320 2+5u 320 2+5u 300 2+5u	240	200
					32 2+5u 80 2+5u 120 4+5u	77			
Fourth	10	68	96	$2\frac{1}{2}$			88 2+5u 60 none+5u 120 2+5u 120 160	110	33
	36			$12\frac{1}{2}$		56		197	141

TEST No. 13.

Machine used: Same as in Test No. 12. Rigged.
Starter: Entirely hollow Star bits.
Other drills: Entirely hollow Star bits.
Dip of hole: 26°.
Natives per machine: One.
Rock drilled into: Hard quartzite.

Drill used.	Depth drilled in inches.	Air pressure lbs. per sq. inch.	Water press. lbs. per sq. inch.	Time drilling in minutes.	Air samples particles per c.c.	Average.	Dust samples particles per c.c. u = micron.	Average.	Corrected dust average nett dust produced particles per c.c.
					60 2 + 5u 30 2 + 5u 42 2 + 5u	44			
Starter	6	68	47	1¾			100 4 + 5u 160 2 + 5u 220 2 + 5u 130 4 + 5u 100 2 + 5u 140 4 + 5u	142	98
					40 2 + 5u 54 4 + 5u 50 2 + 5u	48			
Second	10	68	47	4			220 2 + 5u 200 2 + 5u 220 2 + 5u 200 2 + 5u 200 2 + 5u 180 2 + 5u	203	155
					50 2 + 5u 50 2 + 5u 60 2 + 5u	53			
Third	10	68	47	2¾			Slide spoiled 240 4 + 5u 140 2 + 5u 160 2 + 5u	180	127
					30 2 + 5u 36 2 + 5u 30 2 + 5u	32			
Fourth	10	68	43	2			80 2 + 5u 120 2 + 5u 120 2 + 5u 100 2 + 5u 100 2 + 5u 60 2 + 5u	97	65
	36			10½		44		155	111



AN UNUSUAL PROCESS IN THE TREATMENT OF GOLD ORE."

By B. L. Gardiner, B.Sc. *(Associate).*

(Printed in Journal, January, 1920).

REPLY TO DISCUSSION.

Mr. B. L. Gardiner *(Associate)*: In replying to the discussion on the above paper the author wishes to express his gratification at the way in which it has been received.

Mr. C. J. Gray raises the point as to whether it is common for assays of banded ironstone gold ores to be much higher than panning results. That peculiarity is a feature of most of the banded ironstones that have come under the author's notice in Rhodesia; at any rate, in so far as the oxide zone is concerned, although the ratio is not always as large as seven is to one. On the other hand, certain banded ironstone lodes have, in the sulphide zone, had their contents singularly free, the Giant Mine being a case in point where a recovery of over 80% was made by all-sliming and concentration on blanket strakes.

In direct answer to Mr. Gray's query, the author would say it is always advisable to have at least one or two assays made of banded ironstone gold ores, and never to turn down such a proposition on panning results only.

While thanking Mr. A. F. Crosse, I feel that his remarks call for no reply in particular.

Mr. F. Wartenweiler remarks on the high strength of cyanide solution "0·17%," used in connection with the leaching of the baked ore. The chief reason why this and not a lower strength is used is due to the fact that if a lower strength is pumped on to the vats the effluent solutions fall below 0·07%, and when this takes place trouble is experienced in getting uniformly good precipitation.

It might be feasible to use lower strength solutions by always working up the strength at the heads of the precipitation boxes, but in view of the fact that the time of treatment is limited by the capacity of the cyanide plant, it was deemed inadvisable to do anything in this way, on the general lines that a stronger solution was more likely to give a more rapid extraction of the gold than a weaker one.

Mr. J. Hayward Johnson's contribution is particularly interesting when compared with the Connemara treatment, as the ore of the Machavie G.M. is apparently of a distinctly different type. The writer regrets that in the case of the Connemara he had not the facilities for making complete analyses, but, indirectly, it may be assumed that no ferrous iron is present, or at any rate no iron in a ferrous state likely to cause harm. In practically all cases where such iron is present in an ore the solutions show ferro-cyanide, but in the case of the Connemara solution they are absolutely free from that compound.

As stated in the paper, the solutions are singularly pure and free from the more common compounds which are found in the average working cyanide solution. Qualitative tests give no indications of ferrous compounds or sulphates, and the fact that repeated re-treatment of residues, even after drying gives no further extraction, seem rather to preclude the idea that the low proportion of gold recovered without baking is in any way due to the presence of reducing or oxygen absorbing compounds either in the ore or the solution.

Dealing with the treatment results at the Machavie Gold Mine, the behaviour of this ore with regard to cyanide treatment is rather characteristic of ores containing pyrrhotite. That mineral seems to decompose with cyanide most rapidly, giving ferro-cyanide, $M_4FeC_6N_6$, and thiocyanates, MCNS. The author also has had experience of ores of this nature giving satisfactory extraction results in the laboratory, when using freshly made up solutions, and then when the ore comes to be treated on the working scale it has been found that the extraction begins to fall off with the repeated use of solution. Possibly this may be accounted for in the following way:

When fresh solutions are used the ferrous iron goes straightaway into combination with cyanide, forming the harmless alkaline ferro-cyanides and thiocyanates, and when these solutions become more densely charged as time goes on with ferro-cyanides, then it is possible that any ferrous iron present in the ore will combine directly with the alkaline ferro-cyanide, giving the complex compound ferrous ferro-cyanide $Fe_2(FeC_6N_6)$, a white precipitate which rapidly absorbs oxygen with the formation of blue compounds:

$$3Fe_2(FeC_6N_6) + 3O + 3H_2O$$
$$Fe_2(OH)_6 + Fe_4(FeC_6N_6).$$

The author has on occasions observed a whitish colour in certain sand residues, which changes to blue on exposure to the atmosphere, and there has always been extraction difficulty at the same time. In some instances it is possible to deal with pyrrhotite ore by crushing in alkaline solution with aeration. Apparently in the presence of marked alkalinity the pyrrhotite is not decomposed so rapidly by cyanide.

The remarkable action of partial roasting on the Machavie ore is difficult to explain, since apparently there is no question of burning off the sulphur contents as in usual roasting practice, and it would be most interesting to have some hypothesis set forth to explain the change in the ore. De-hydration does not seem to be a likely explanation in connection with the sulphide ore unless there is definite evidence of hydrates being present, which is an unlikely contingency. Possibly the heat alters the nature of the gold by causing some other coating substance to be removed or disintegrated.

Mr. J. A. Woodburn's comments give rise to a train of thought, and in view of the fact that the Connemara gold is so exceedingly fine, it has occurred to the author that there may be a possibility of some of the products of decomposition of the original sulphide lode being themselves solvent of gold. For instance, chloride of iron is said to have this power. If some of the other compounds, such as sulphates, also can act in this way, such action would form a good explanation for the enrichment of the Connemara lodes, which very distinctly give the best values right on the contact with the sulphide ore, decreasing as the surface is approached, the actual outcrop for the most part being relatively barren. Solution of gold, with precipitation at the lower portion of the lode, would also explain the very fine state of division in which it occurs. Perhaps our chemists or geologists could throw a little light on that.

With regard to the increased consumption of lime after baking, the explanation may be that the baking has considerably increased the porosity of the ore, and that the solutions therefore come in contact with a larger quantity of alkali destroyer, be it ferric sulphate or any other substance.

The reasons for the differences in extraction obtained on ore from different parts of the mine are mainly deductive. The opinion is advanced that it is due to more inti-

mate association of the gold with limonite in some instances than in others. Sometimes the amount of visible gold is a lower proportion than 7:1, which is given as a round average ratio. All the gold liberated by crushing appears to amalgamate readily enough, as the tailing leaving the plate shows nothing in the pan, and the difficulty in extraction appears to lie with what might be termed "invisible" gold. More recently a portion of the mine has been developed, where ore assaying over 20 dwt. per ton has shown a meagre tail of free gold equivalent to ½ dwt. only in the pan, and this ore appears to be giving more trouble than usual in its treatment.

THE IDENTIFICATION OF QUARTZ PARTICLES IN KONIMETER SAMPLES.

By Dr. A. W. Rogers, F.R.S. (Member).

(Printed in Journal, April, 1920.)

DISCUSSION.

Dr. J. Moir *(Past-President) (contributed)*: Since I made my first contribution* to this discussion I have made some further experiments, the results of which are of some importance, and should be recorded. On trying orthotoluidine of index 1·57 on dry quartz and mica dust I found that it worked well, but on trying it on konimeter samples it was a failure, because it did not dissolve vaseline sufficiently. Dimethylaniline, which I had also suggested as a single liquid capable of doing the work, was found to dissolve vaseline well enough, but I was surprised to find that when tried on konimeter samples it rendered the quartz dust almost totally invisible. I found the explanation to be that the vaseline lowers the refractive index much more than had been expected, so that the solution of vaseline in dimethylaniline had exactly the same index as the average of quartz.

I then examined the bromoform and brombenzene actually in use by Mr. Atkin, since an equal-volume mixture of these was giving good results. This mixture had an index of 1·587 (instead of 1·570 as suggested by Dr. Rogers' table on page 178); the bromoform had an index of 1·598, and smelt decidedly of carbonylbromide, $COBr_2$ (*cf.* phosgene), due to decomposition by light. A newly-imported sample of bromoform had the index 1·600, had only a sweet smell, and did not react with bromobenzene to give crystals (*cf.* Mr. Atkin's remarks), the crystals being therefore due to the carbonylbromide. I should therefore like to know where Dr. Rogers got the figure 1·58 for bromoform given at the beginning of page 178.

The inference for the moment, then, was that Dr. Rogers had got caught in a fallacy in counting as quartz everything below 1·59 instead of 1·57, but further experiment showed that there is really no fallacy, but that the vaseline lowered the index back from 1·59 to near 1·57 in practice. The only error in the paper therefore is in leaving it to be inferred that the liquid to be used should have the index 1·57, whereas it should be 1·59.

I have examined a number of liquids to find if there is any common one with index 1·59 at 20° (white light), but have been unsuccessful in finding one which also dissolves vaseline. For the present I recommend a mixture of five parts of bromobenzene with 1 part of alphabromonaphthalene, which is permanent, gives no crystals on keeping, is practically non-volatile, and dissolves vaseline quite easily. Four parts of this mixture, plus one part of vaseline of index 1·492, would have the index 1·570, the required one, and the other experiments suggest that the vaseline does form about 20% of the mixture under the cover-glass.

THE GOLD PREMIUM.

By S. Evans (Associate).

(Printed in Journal, May, 1920).

DISCUSSION.

Mr. E. M. Weston *(Member of Council)*: The author's paper is one of the most lucid and concise discussions on the money question that I have ever had the pleasure to read. As one who first brought this matter up for discussion before a scientific society in Johannesburg in a paper entitled "Gold

*In this for *refractory* read *refractive*.

Production in Relation to Humanity,"* April, 1913, this subject is of particular interest to me. In that paper and in my reply to discussion I brought forward facts to show that even in 1913 there was a real shortage of gold in the world rather than, as Prof. Lehfeldt and others have maintained, a surplus which tended to raise prices. We are apt to forget to-day that the rising cost movement began before the war. The true reasons for that tendency I tried to set out in detail, and I think any impartial investigator will refuse to believe with Prof. Lehfeldt that the output of gold to 1915 increased at a greater rate than the expansion of trade and markets and the needs of new countries adopting a gold standard. To any one with any knowledge of mining geography and geology it was quite easy to make certain predictions which have since proved to be well founded. It was evident in 1913 that the curve of gold production was reaching its highest point, and that nothing could then prevent a definite or rather rapid decline; while at the same time it was evident that the growth of the world's population and of the world's trade must for many decades show a steadily rising curve which must reflect itself even in normal times in a demand for increased currency. It also was not hard to predict that in the event of war, governments would base their money issues on the credit of the country's possessions and suspend gold payments. I thus wrote having in my mind rather a decrease of gold output in relation to trade, than an immense inflation of credit money due to war.

"One might guess that within a decade bi-metallism will again be talked about and one might dream of a future gold trust demanding £6 per oz. for the world's production."

Let us now note what has happened to gold production, as shown in the following table:

	Australia. 1000 oz.	Russia. 1000 oz.	U.S.A. 1000 oz.	Africa. 1000 oz.	Total value in £.
1911 ...	2,911	1,555	4,687	9,366	92,947,000
1915 ...	2,389	1,273	4,888	10,598	96,647,000
1916 ...	1,954	1,088	4,479	10,713	93,007,000
1917 ...	1,738	871	4,051	10,381	87,042,000
1918 ...	1,536	580	3,321	9,542	78,776,000
1919 ...	1,337	556	2,829	9,354	75,032,000

Not one of these countries has the slightest hope of ever regaining its 1915 output. In fact during the next decade the decline will be most rapid except perhaps in the case of Russia, Arabia, Central Africa and Canada. Now, the question I wish the author and the other champions of the normal gold standard to answer is. How do they propose to supply the world's gold needs in the face of these facts? They may propose to adopt bi-metallism; but the output of silver is already sinking, and not equal to the demand. There seems no other course (no matter how many objections may be made to it) than to do what Caesar and Charles V. did in probably similar circumstances, and that is to increase the price of gold. Whether it could be done permanently in the face of the opposition of those countries which have little gold, and perhaps of America, I do not care to say. I should however like to point out that even this course would have only a temporary effect on the problem; unless it were possible to increase the value every decade or so. Even with gold at £6 per oz. the production of gold cannot be stimulated beyond a certain extent. There are not in the gold fields of the world huge deposits of very low grade gold ore that, with a high price for gold can be drawn upon to maintain an output to supply the growing needs of the world. In my opinion in a few years it will be seen that gold is going to be a rare mineral.

Book Reviews.

COMPRESSED AIR PLANT. By ROBERT PEELE, Mining Engineer and Professor of Mining in the School of Mines, Columbia University. Third Edition, largely re-written. New York: John Wiley & Sons, Inc. London: Chapman & Hall, July, 1918. 485 pp. and numerous illustrations. Price £1 nett.

The second edition of this work, though printed in 1913 had fallen somewhat out of date owing to improvements in compressor design and the increased importance of hammer-drills. Several chapters have accordingly been expanded and a few have been entirely re-written.

In a work dealing with the production transmission and use of compressed air it is not of course possible to avoid the use of higher mathematics. In this case the equations used are derived as simply as possible, and there are no irritating gaps in the proofs covered by the usual inade-

*This *Journal*, Vol. XIII., April, 1913, p. 472.

quate formula "it can easily be seen."

Full justice is done to the differences in compressor performances due to high altitudes, such as are common in mining districts and the modern makes of drilling machines are clearly explained while their performances are compared. The increasing use of Pohlé air lifts is thoroughly dealt with in Chapter XXV., and the converse operation of compressing air by direct action of falling water in Chapter XV.

Explosions in compressors and receivers are dealt with in Chapter XIV., and the usual theories advanced in explanation are stated to be unsatisfactory while further research on this important subject is suggested as suitable for mechanical engineering laboratories.

The book is produced in excellent style, and is very free from typographical errors, while the illustrations and diagrams are exceptionally free from defects.

(H. A. W.)

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

International Atomic Weights, 1920.

	Symbol.	Atomic weight.
Aluminium	Al	27·1
Antimony	Sb	120·2
Argon	A	39·9
Arsenic	As	74·96
Barium	Ba	137·37
Bismuth	Bi	208·0
Boron	B	10·9
Bromine	Br	79·92
Cadmium	Cd	112·40
Caesium	Cs	132·81
Calcium	Ca	40·70
Carbon	C	12·005
Cerium	Ce	140·25
Chlorine	Cl	35·46
Chromium	Cr	52·0
Cobalt	Co	58·97
Columbium	Cb	93·1
Copper	Cu	63·57
Dysprosium	Dy	162·5
Erbium	Er	167·7
Europium	Eu	152·0
Fluorine	F	19·0
Gadolinium	Gd	157·3
Gallium	Ga	70·1
Germanium	Ge	72·5
Glucinum	Gl	9·1
Gold	Au	197·2
Helium	He	4·00
Holmium	Ho	163·5
Hydrogen	H	1·008
Indium	In	114·8
Iodine	I	126·92
Iridium	Ir	193·1
Iron	Fe	55·84
Krypton	Kr	82·92
Lanthanum	La	139·0
Lead	Pb	207·20
Lithium	Li	6·94
Lutecium	Lu	175·0
Magnesium	Mg	24·32
Manganese	Mn	54·93
Mercury	Hg	200·6
Molybdenum	Mo	96·0
Neodymium	Nd	144·3
Neon	Ne	20·2
Nickel	Ni	58·68
Niton (radium emanation)	Nt	222·4
Nitrogen	N	14·008
Osmium	Os	190·9
Oxygen	O	16·00
Palladium	Pd	106·7
Phosphorus	P	31·04
Platinum	Pt	195·2
Potassium	K	39·10
Praseodymium	Pr	140·9
Radium	Ra	226·0
Rhodium	Rh	102·9
Rubidium	Rb	85·45
Ruthenium	Ru	101·7
Samarium	Sa	150·4
Scandium	Sc	44·1
Selenium	Se	79·2
Silicon	Si	28·3
Silver	Ag	107·88
Sodium	Na	23·00
Strontium	Sr	87·63
Sulphur	S	32·06
Tantalum	Ta	181·5
Tellurium	Te	127·5
Terbium	Tb	159·2
Thallium	Tl	204·0
Thorium	Th	232·15
Thulium	Tm	168·5
Tin	Sn	118·7
Titanium	Ti	48·1
Tungsten	W	184·0
Uranium	U	238·2
Vanadium	V	51·0
Xenon	Xe	130·2
Ytterbium (Neoytterbium)	Yb	173·5
Yttrium	Yt	89·33
Zinc	Zn	65·37
Zirconium	Zr	90·6

In the above table of atomic weights proposed for 1920, few changes have been made from the values given in the last preceding table. The new values are A = 39·9 ; B = 10·9 ; Ga = 70·1 ; Th = 232·15 ; and Yt = 89·33. In addition to these the atomic weight of nitrogen should be changed from 14·01 to the more precise value 14·008. The latter figure represents all the best determinations, and is probably correct to within 1 in the third decimal place. For so small a value the change is insignificant.—F. W. Clarke, T. E. Thorpe, G. Urbain, *Journal, American Chemical Society*, Dec., 1919, p. 1886. (H. A. W.)

Rapid Determination of Carbon Monoxide in Air.—In order to test gas mask absorbents for CO, a rapid method for the estimation of one per cent. and under in air became necessary. Two methods depending on the combustion of the CO and measurement of the temperature rise were developed.

In one method the air containing the CO is led first over an electrically heated platinum wire, then over copper oxide to complete the combustion and finally over a second platinum wire heated to the same temperature as the first. The two platinum wires form two arms of a wheatstone's bridge arrangement, so that the measurement of the temperature rise depends on the use of a platinum resistance pyrometer.

The second method which was more fully developed and is easier to carry out was used in routine testing for many months. In this method the combustion of the CO is effected by leading the air first through a coiled glass tube heated by means of a vapour bath from boiling diphenylamine to about 300° C., and then over platinum black deposited electrolytically on a coil of platinum wire. Situated near the catalyst is a copper—constantan thermocouple connected with a galvanometer, etc. The thermo couple pyrometer is calibrated by means of samples of air containing known quantities of CO; *e.g.*, ·25 per cent. to 1·0 per cent. These samples can be prepared synthetically, or, as was found better, analysed by means of the iodine pentoxide method. Certain precautions are necessary in order to keep the catalyst active, but it is stated that the method is both accurate and rapid. —Lamb and Larson, *Chemical News*, from *J. Am. Chem. Soc.*, Feb. 6, 13, and 20, 1920, pp. 61 and 62, 81 and 82, 85 and 86. (H. R. A.)

Calcium Cyanide.—"The author gives some particulars of the low grade calcium cyanide for use in gold and silver metallurgy by the American Cyanamide Co. It is produced by heating a mixture of cyanamide and common salt at a high temperature in an electric furnace. It was not a commercial success in Germany when tried about 15 years ago, but in 1916 owing to scarcity of cyanide in America the Cyanamide Co. revived it with success, and the development has been rapid.

The following figures of output are given:

	Production equivalent to 100% NaCN.
1917	2,187,000 lb.
1918	2,350,000 lb.
1919	4,000,000 lb. (calculated 7 months)

The product at the start contained about 14% equivalent to NaCN, but in 1919 was 36·37% NaCN, and occasional products run as high as 50% NaCN.

Many patents cover the process, but the present practice, cyanamide, salt and calcium carbide are mixed together and fed continuously to a single-phase furnace having a very small cubical capacity as compared with the power input. The fused product is removed almost continuously to a cooling device to prevent a reversible action. The marketable product is in the form of small thin greyish black and shiny black scales. It appears to be a mixture of calcium cyanide, sodium chloride and free lime with very small quantities of calcium carbide, calcium cyanamide and impurities resulting from coke used in the manufacture of the cyanamide. Two grades are prepared, viz., Aero Brand Cyanide, "Grade X," equivalent to 36·37% NaCN and Aero Brand, "Grade XX," equivalent to 45% NaCN. The cost is materially less than the purer forms of cyanide hitherto on the market.

It has been found in practice that it is of equal efficiency in dissolving gold and silver to the 98% grade NaCN on the marked and the accumulation of soluble salts resulting from its use does not prove troublesome. The small quantity of carbonaceous material present has no precipitating effect. The sulphur present is quickly aerated and converted into compounds having no detrimental effect."—W. S. Landis, *Chemical and Metallurgical Engineering*, Feb. 11, 1920.—*The Mining Magazine*, April 1920, p. 252. (W. A. C.)

Abstract of Patent Applications.

278.19. P. O. Rowlands. Improvements in or relating to internal combustion engines and vaporisers therefor. 16.4.19.

This application refers to a carburettor for internal combustion engines in which a constant liquid level is maintained by the overflow of excess fuel. Further claim is for pre-heating in the carburettor of the liquid fuel so as to increase the volatility of the fuel used.

771.19. W. Gallagher. Improvements in means or instruments for use in surveying boreholes and the like. 23.9.19.

The instrument is made up of an outer casing, inside of which is a longitudinal carrier which supports a plumb-bob and a magnetic needle, which may be locked and released by clockwork mechanism supported on the same carrier as part of the instrument.

Briefly, the operation is that the instrument is lowered into a borehole with a plumb-bob and needle locked, the clockwork having been set in motion. After a given period the plumb-bob and needle are released, and after another period sufficient to give them time to come to rest, they are clamped by the clockwork mechanism. The instrument is then withdrawn, and the inclination and direction of the hole at the position where the instrument was brought to rest can be read directly from graduated scales forming part of the plumb-bob and needle box arrangement.

892.19. G. van Oordt. Process for increasing the hardness and tenacity of metals and ease of their working with cutting tools. 7.11.19.

This application refers specific means of hardening, more especially aluminium, castings, etc., by a prolonged treatment at a temperature below the characteristic for the purpose of making such metals fit for machining.

897.19. Merz and McLellan. Improvements in or relating to distillation of fuel. 7.11.19.

This specification describes a method for preheating charges of fuel before being admitted into the retort for low-temperature distillation, the fuel

being heated by the passage of superheated steam or other hot gases through it (without external heat) to a temperature above the temperature of the condensation of the distillate, but not high enough to cause any appreciable decomposition of the fuel.

946.19. Merz and McLellan. Improvements in or relating to retorts and the like. 21.11.19.

This specification describes an apparatus for the charging of retorts for low-temperature distillation of fuel, whereby the fuel may be introduced without creating dust in the retort, and thus avoiding fine dust being carried through to the condensors and bye-product plant.

The apparatus consists of one or more feeding-conduits entering the sides of the retort, such conduits being fed by rotating worms or oscillating plungers to propel the fuel along the troughs, and pile it up to the height intended.

954.19. Penhale and Treloar. Improvements in the treatment of antimonial and arsenical gold ores.

This application relates to the treatment of gold-bearing ores containing sulphides of antimony and arsenic, with the object of producing a product which is amenable to treatment by the cyanide process.

The ore is crushed to a fine state of division in an aqueous solution of an alkali metal sulphide, which solution, it is claimed, dissolves the sulphides of antimony and arsenic from the ore. The liquid is then separated from the ore, which is now in a suitable condition for the solution of the gold by means of the cyanide process.

The arsenic and antimony may be recovered from the liquid by known methods.

1053.19. A. C. Anden. Improvements in the method of extracting potash from potash-bearing minerals, and the manufacture of the residual products of such method of conversion into cement. 19.12.19.

This application refers to :

1. In the manufacture of potash salts from potash-bearing minerals. The method of incomplete roasting of a mixture of such potash-bearing mineral, lime and salt and the subsequent sieving out and regrinding of the coarser parts of such roasted mixture and the retreatment of the whole of the re-ground material by re-roasting, re-sieving and re-grinding, of the portions which do not pass the sieve as described.

2. In the manfacture of potash salts from potash-bearing mineral where such potash-bearing mineral is a silicate of iron and potash such as glauconite, the treatment of a mixture, (after roasting and sieving as described in claim 1) of the said potash-bearing mineral lime, and salt with steam, either saturated or superheated, and hot water in a closed vessel, *e.g.*, an autoclave and the agitation of the contents of the said closed vessel substantially as described.

3. In the manufacture of white cement the application of the residue left from the manufacture of potash salts as claimed in claims 1 and 2 to form in combination with gypsum in the manner commonly known, a cement, substantially as described.

113.20. C. L. Stokoe. Safety apparatus actuated on the failure or commencement of the flow of a fluid through a pipe. 5.2.20.

The application covered by this specification is an application of the well known flap or disc valve placed inside a pipe and commonly used for the atmospheric exhaust of condensing steam engines.

Indication of the commencement of cessation of flow of fluid in the pipe is communicated by means of a spindle and levers to apparatus outside the pipe, the object being to give a warning by bell, light or whistle.

The means proposed for giving the warning are :

(1) Making or breaking electrical contacts.

(2) Operating positive or trip gears.

The uses suggested by the applicant include indication of failure of :

(1) Cooling water supply to air compressors.

(2) Cooling water supply to jackets of gas and oil engines.

(3) Cooling water supply to condensers.

(4) Flow of liquids in chemical plants.

(5) Flow of brine in refrigerating plants.

(6) Flow of liquid fuel for internal combustion engines.

(7) Flow of lubricating oil to bearings or gearing.

(8) Flow of steam.

(9) Steam, air or electric pumps.

The claims put forward are :

1. A general claim covering safety apparatus actuated by the failure or commencement of the flow of a fluid through a pipe, in which a movable member arranged transversely across the pipe communicates with an indicating or safety device outside the pipe.

2. Flap valve inside the pipe making and breaking electrical contact by means of a spindle extending to the outside of the pipe.

3. Disc valve inside the pipe making and breaking electrical contact by means of a spindle extending to the outside of the pipe.

4. Flap or disc valve inside the pipe operating by means of a spindle a mechanical indicating gear outside the pipe.

5. The improved safety apparatus actuated as described above and constructed, arranged and adapted to operate as shown in the drawings.

142.20. John Spencer, Ltd. Improvements in and relating to pipe and like joints. 19.2.20.

This application refers to improvements in and relating to pipe and like joints, and claims to provide a cheaper and more effective method of forming pipes.

The applicant states that a defect in ordinary mild steel pipes formed with rolled flanges for jointing is a certain weakness where the metal is more or less abruptly bent over to form the flange, and he proposes to obviate this by expanding a limited length of the pipe in the neighbourhood of the flange to a diameter sufficient to receive an internal stiffening ring of the same internal diameter as the pipe, which ring is then autogenously welded in position.

143.20. John Spencer, Ltd. Improvements in and relating to pipe and like joints. 19.2.20.

This application refers to improvements in pipe and like joints of the type in which welding metal is used to seal certain portions of the joint, and

states that the object is to provide a secure welded joint for pipes, cheap to carry out and efficient in use. The applicant proposes to join together pipes on which small flanges have been previously formed by ring or strip sections of trough form which embrace the flanges and are welded to the pipes. These strip sections of trough form may embrace the whole or any portions of the circumference of the joint in which latter case the portions of the flanges uncovered by the trough sections are welded together.

184.20. F. Uhlig. Improved collector for magnetic concentrators. 3.3.20.

This application relates to an improved collector for magnetic separators, and consists of a receiver or tray for holding the extracted material, said tray being automatically brought into position by the interruption of the current passing through the magnet. It is claimed that by this means the extracted material is prevented from getting mixed with the gangue or unseparated material.

193.20. McKenzie Holland, Westinghouse Power Signal Co., Ltd., and F. M. Castleman. Improvements relating to loading and unloading gear for hoisting plant and the like. 5.3.20.

This application is for improvements relating to loading and unloading gear for hoisting plant and the like. The claims are five in number, and are as follows:—

1. Loading and unloading gear for hoisting plant and the like, comprising a winding cage having one or more decks and arrangements for loading and unloading empty and full tubs or trucks respectively on to and from the winding cage by means of one or more power operated rams in which the control mechanism for the power operated rams is arranged to be electrically interlocked with mechanism for securing the winding cage in position during the loading and unloading operation for the purpose specified.

2. Loading and unloading gear of the kind specified in claim 1 in which the power operated rams are arranged to be automatically returned to their inoperative position after the loading and unloading has been completely effected, for the purpose specified.

3. Loading and unloading gear of the kind described in which the operation of the power operated ram mechanism is arranged to be controlled by indication devices dependent upon the position of the winding cage and of the hoists or other arrangements provided for accommodating the empty and full tubs with or without an additional manually operated control mechanism for effecting the operation of the ram mechanism, for the purpose specified.

4. An automatic electric control system for loading and unloading gear of the kind described, comprising one or more power operated rams and motor devices for operating keps adapted to secure the winding cage in position, the ram mechanism and the motor devices being provided with electro magnetically actuated valves, the control circuits for which include indication devices operated by the keps and rams with relays or their equivalent for causing automatic return movement of the rams after the loading and unloading operation has been completed substantially as and for the purpose specified.

5. An automatic electrically controlled interlocking system for loading and unloading gear of the kind described, comprising a manually operated control lever provided with switch contacts, indication circuits connected to the various indication contacts, relay devices and electro-magnetically actuated valve mechanism connected, arranged and operating substantially as described with reference to figures 1, 2 and 3 of the accompanying drawings.

216.20. J. C. Grant. Improvements in and relating to liquid raising apparatus. 11.3.20.

This application refers to chains made of a multiple of interlacing helices arranged with their axes at right angles to the length of the chain, or a modification by means of rings or by plates between rings for the purpose of raising water according to the principle of the "chain helice pump."

222.20. U. C. T. Martinez. Electrolytic cell. 11.3.20.

This application relates to an electrolytic cell, and one of the objects of the application is the treatment of relatively large quantities of solution in a very rapid and thorough manner.

The object is to provide a cell comprising a casing in which is mounted a plurality of fixed electrodes and a plurality of intermediate revolving electrodes with the necessary partitions and arrangements to ensure suitable electrolytic action and deposition.

Changes of Address.

BROWNE, C. H., *l/o* City & Suburban G.M. Co., Ltd.: Village Main Reef G.M. Co., Ltd., P.O. Box 1091, Johannesburg.

CAZALET, P., *l/o* Johannesburg: White River, *via* Nelspruit, N.E. Transvaal.

GARDINER, B. L., *l/o* Connemara Mine, Rhodesia; c/o Willoughby's Consolidated Co., Ltd., P.O. Box 220, Bulawayo.

GILBERT, T. W., from Active Service; North Randfontein G.M., Randfontein.

MANCE, Major J. C., *l/o* Sandy, Beds.; c/o Messrs. Bird & Co., P.O. Box 221, Mombasa, British East Africa.

MELVILL, G., *l/o* Village Deep, Ltd.: Consolidated Main Reef Mines & Estate, Ltd., P.O. Box 2, Maraisburg.

ROBERTSON, L. A., *l/o* New Goch G.M., Ltd.; c/o Manager, Witbank Collieries, Witbank, Transvaal.

SHARPLEY, H., *l/o* Mt. Morgan Mine, Barberton; c/o I. M. Riggall, Esq., Hackthorn, Lincoln, England.

SOLOMON, L., *l/o* Johannesburg: P.O. Box 10, Davel, Ermelo District, Transvaal.

STUART, F. A., *l/o* Dundee: Northfield, Glencoe Junction, Natal.

THOMAS, F. J., *l/o* Selukwe: Eileen Alannah Mine, Eiffel Flats, Rhodesia.

WRAITH, C. O., *l/o* Elizabethville, Congo Belge; c/o National Bank of South Africa, Ltd., Simmonds Street, Johannesburg.

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A RESUME OF LITERATURE ON THE THEORY OF FLOTATION WITH CRITICAL NOTES.

By H. R. Adam, B.Sc., F.I.C. *(Member).*

In the following paper I propose to give a summarised version of the theoretical information that has accumulated within the last five or six years in connection with flotation processes for the concentration of ores. Papers on this subject have appeared chiefly in the scientific and technical journals devoted to mining and metallurgy, although it is noteworthy that physicists are now becoming more directly interested. Naturally the written information obtainable on both the practical and theoretical aspects of flotation is still very much scattered and as several important contributions to theory have been published without discussion or criticism it is by no means an easy matter to compare the data available or the statements founded thereon. The matter in this paper is classified not according to the dates on which publications have appeared, but according to what have seemed to the writer to be the different phases of the subject, and in adding critical notes he is giving in a general way the results of his own observations and experimental work. For the sake of clearness it was thought advisable to include a good deal of what may be considered by many to be rather elementary and out of date information.

Conditions for equilibrium when a solid is in contact with two fluids.—These are the apparent conditions in a mixture of ore particles and water during the application of the various methods of flotation: the ore particles represent the solid while the fluids are water, more or less modified by the addition of various "reagents" and gas or gases, the latter in the form of minute bubbles. Before examining the statements of writers on flotation theory under this heading the equation representing the equilibrium as given by Clerk Maxwell [1] should be studied. "The equilibrium of the tensions concerned depends only on that of their components parallel to the surface because the surface tensions normal to the solid surfaces are balanced by the resistance of the solid. Hence for equilibrium.

$$T_{sg} - T_{sl} - T_{lg} \cos \theta = O$$

$$\text{whence } \cos \theta = \frac{T_{sg} - T_{sl}}{T_{lg}} \text{"}$$

Poynting and Thomson [2] deduce a similar equation.

Edser [3] arrives at a similar result although in a somewhat different manner. His reasoning is especially interesting since he assumes that the tension T_{sl} is a residual tension. "When the liquid comes in contact with the solid the surface of the solid will be partly relieved of its strain by the attraction of the liquid molecules and similarly with the liquid molecules." "Therefore when wetting takes place $T_{sl}=0$ *e.g.*, water/glass. When there is absolutely no wetting $T_{sl} = T_{sg} + T_{lg}$ and $\theta = 180°$, cos θ in this case being -1: such a condition is approached by the contact of mercury and clean glass."

*In order to avoid confusion the symbols used by various writers which, naturally vary, have been put in the one form.

T_{sg} = surface tension solid-gas.
T_{sl} = surface tension solid-liquid.
T_{lg} = surface tension liquid-gas.
θ = the contact angle.

Edser, therefore, assumes that T_{sl} simply depends on T_{sg} and T_{lg}; this is doubtful since new conditions may arise on account of chemical or electromagnetic action at the solid—liquid surface or interface ([4]). According to Hatschek ([5]) there is no proof that in suspensions T_{sl} can be reduced to zero.

It will be seen from Clerk Maxwell's equation that an increase in the angle of contact means that T_{sl} increases relatively to T_{sg}. If we look at the matter from the aspect of the principle of minimum potential energy it becomes clearer. The greater T_{sl} the greater will be the tendency to reduction in the area of contact of solid and liquid and it follows that θ will increase; conversely if T_{sg} is large the tendency will be towards a reduction of the interface solid—gas, which can be done by the spreading of the liquid with consequent decrease of θ.

The following applications of this theory to flotation have been made:—

O. C. Ralston ([6]) and Corliss and Perkins ([7]) state the relationships in the form used by Freundlich ([8]) (p. 174) for the distribution of colloidal particles in two liquid phases.

Since Ralston confines his statement to two liquid phases, oil and water, and since in modern flotation it is probably more correct to consider only the two fluid phases "contaminated water" and gas—only the statement according to Corliss and Perkins need be repeated.

These writers state that either

(1) $T_{sl} > T_{sg} + T_{lg}$

or (2) No one interfacial tension is greater than the sum of the other two.

They further state that the condition (3) $T_{lg} > T_{sg} + T_{sl}$ is impossible and that case (2) is the actual one in flotation. For complete wetting, *e.g.*, gangue, the condition is $T_{sg} > T_{sl} + T_{lg}$; whilst conditions (1) and (3) would imply complete non-wetting.

This argument is in accordance with the Clerk Maxwell equation, but it must be pointed out that condition (2) implies that a triangle could theoretically be constructed with sides proportional to the three tensions. According to Clerk Maxwell, both experimental work and theoretical reasoning support the view that this condition is imaginary and where it apparently occurs, one or more of the surfaces is contaminated; that is where spreading of the liquid does not occur we are not dealing with true contact of the surfaces. It is, however, probably quite justifiable to consider the case in the manner of Corliss and Perkins, since in flotation the surfaces almost certainly are contaminated, but due consideration of the matter is important in view of the discrepancies, in the results obtained for contact angles, to be mentioned later.

Taggart and Beach ([9]) state the equilibrium equation as

$$T_{sl} = T_{sg} + T_{lg} \cos\theta \text{ from which}$$

$$\cos\theta = \frac{T_{sl} - T_{sg}}{T_{lg}}$$

This means that a large contact angle will be the result of a low T_{sl} and relatively high T_{sg}, *i.e.*, a tendency for the liquid to wet the solid, which is obviously incorrect. Salman ([10]) gives the relationship in the manner of Edser ([3]), and evidently regards the tension at the solid—liquid interface as a residual tension greater or less according as wetting is partial or complete. Sulman's explanation of the matter is made the more lucid since he discusses the various possibilities according to the variation of the contact angle between 180° and zero.

In a paper on the theory of wetting Cooper and Nuttal ([11]) state the equilibrium equation and give a very clear explanation of the conditions which may obtain. As these writers have approached the matter from an entirely different standpoint from that of flotation, it is of interest to summarise their article even at the risk of considerable repetition. They quote Quincke as being the first to state the conditions for wetting which, using the same symbols, are:

"(*a*) That T_{lg} should be low
(*b*) ,, T_{sg} ,, ,, high.
(*c*) ,, T_{sl} ,, ,, low."

Cooper and Nutall emphasise that in regard to wetting it is not sufficent to regard only the surface tension of the liquid, since even though T_{l}, be high, wetting may occur if T_{sl} is low. The factors influencing T_{sl} are:

(1) The chemical or solvent action of the liquid on the surface layer of the solid; (2) adsorption of dissolved substances at the liquid surface, which occurs when such a concentration causes a decrease in the surface tension of the liquid. The point made with regard to this adsorption is that it is accompanied by increased viscosity at the surface, and that there appears to be a close

connection between superficial viscosity of liquids and their wetting power for solids; further reference to this will be made in a later paragraph. From the point of view of flotation the value of the work of Cooper and Nutall lies chiefly in the emphasis laid on the interfacial tension T_{sl}. In the cases which they are considering, viz., the wetting power of dips and insecticides, the possibility of chemical or solvent action at the solid-liquid interface is obvious. In flotation the complexity increases, and we have to consider possible factors influencing T_{sg} and T_{lg}, while the work of Langmuir and Harkins already referred to indicates that new conditions may arise at the solid—liquid interface affecting T_{sl}[5].

The Contact Angle.—From the foregoing discussion of the equilibrium equation it is clear that the contact angle is practically the only quantitative guide to the relative tensions. It may be remarked at once that from the practical point of view, measurements of contact angles are probably of little value in flotation. Even with the utmost precaution against contamination physicists are unable to arrive at close agreement, and it is evident that the most minute alterations in the conditions obtaining at the surfaces of the three phases may affect the angle considerably.

Freundlich ([8]) (p. 18) expresses considerable doubt on the question of contact angles and states that where a positive angle is obtained it may be due only to contamination of the surfaces. He further states that it is generally concluded that complete wetting means a zero contact angle. In the case of metals, however, the evidence is in favour of a positive angle though the results are in such poor agreement that they can hardly be relied on quantitatively. In the case of glass and water it appears almost certain that if a clean surface is dealt with the angle is zero; for metals Kaye and Laby ([12]) give the angle as varying between 3° and 11°.

To the writer's knowledge the only two papers on flotation theory giving data on contact angles are those of Corliss and Perkins ([7]) and Sulman ([10]). The former contributors do not attempt direct measurement of the angles but give the related values of the rise of the meniscus of the liquid against the mineral surface.

For pure water, taking the rise against the surface of the silicate (which silicate is not mentioned) as unity, the rise against chalcocite is 0·5, and for chalcopyrite 0·8; for 0·1 per cent. H_2SO_4 the ratios are, silicate 1, chalcocite 0·6, chalcopyrite 0·8, and for 0·1 per cent. NaOH, silicate 1, chalcocite 0·9 and chalcopyrite 0·9. Corliss and Perkins also found that when the second fluid was an oil mixture such as is used in flotation, instead of air, the contact angle of the mineral with the water was over 90°.

The most recent figures for the contact angles of minerals and water are given by Sulman ([10]) (p. 48). It is stated that minerals have a maximum and minimum angle with water and the difference between the maximum and minimum is called the "hysteresis." Sulman states that the hysteresis has important effects in flotation. The most noteworthy points in Sulman's investigation are (1) The magnitude of the angles, *e.g.*,

	Minimum.	Maximum.
Stibnite	24·0°	62·8°
Calcite	39·6°	85·5°
Glass	33·0°	39·5°
Quartz	19·5°	58·5°
Chalcopyrite ...	37·0°	87·0°
Galena	35·0°	73·0°

(2) The small differences between two such minerals as quartz and stibnite (stibnite is one of the most easily floated sulphides).

(3) The hysteresis—Corliss and Perkins ([7]) also refer to this hysteresis and suggest an explanation on the basis of the smoothness of the mineral surface. Sulman (p. 50) refers to a "molecular interlocking of the liquid and the solid."

In view of the doubt regarding contact angles, Sulman's figures are distinctly surprising and can hardly be accepted as final, although it is stated that the figures have been confirmed by two different methods. The writer has made several attempts to arrive at satisfactory conclusions for the contact angles of a few minerals with water. The results obtained were somewhat varied but on the whole indicated that when examination is made immediately after immersion in water the contact angle is either zero or very small in the cases of chalcopyrite, galena, marcasite, stibnite, quartz and calcite. The faces examined were, however, not natural cleavage planes but surfaces obtained by polishing with a fine jeweller's file*. There

*See reply to discussion, H. L. Sulman—*Bull. I.M.M*, Jan. 1920, pp. 41 and 42.

is, however, a very distinct difference in the behaviour of these minerals. The sulphides only give the zero angle if examined directly after being immersed in water; if the surfaces are merely touched with a piece of filter paper and then examined again, positive contact angles up to 90° or more are easily obtained. The inference is that sulphides "adsorb" films of air or oxygen with extreme rapidity and in this condition resist the spreading of the water to a greater or lesser extent. It is hoped to give the method of procedure and more detailed results of these investigations at a later date, at present the results are hardly conclusive.

Adsorption of gases at the surfaces of minerals. Although several writers on flotation—Rickard ([13]), Sulman ([10]),—have stated that the adsorption of gases on mineral and metallic surfaces is of minor importance in flotation, the evidence in experimental investigations is to the contrary, at least, as far as theoretical explanations are concerned. The probabilities are that the tendency which nearly all solids show to condense or "adsorb" gas on their surfaces is closely connected with the variability of the contact angle and consequently with the interfacial tensions of solids with liquids and gases. It is true that oil is used in nearly all recent flotation methods, but there is no reason to suppose that this involves great changes in principle since the essential features can easily be manifested without oil. The fact that oil or oils are necessary in practice has tended to obscure the main problem, which is the cause of the preferential adhesion of gas bubbles to sulphides and metals. Unfortunately the knowledge of the causes and effects of gas adsorption on solid surfaces is very limited. Sulman states that "Edser has disproved the air film theory since such a condensation must involve a considerable quantity of gas . . . readily appreciable by chemical and physical means." He further states that

"(1) Pure air is not condensed to any appreciable extent on blende, quartz or galena.

(2) That CO_2 is minutely adsorbed.

(3) That a gas free mineral floats at an air free water surface, *i.e.*, in vacuo, with the same ease as at a water air surface."

These statements are of a very controversial nature. It is well known that solid surfaces, particularly metals, do adsorb or condense appreciable quantities of gases and although this property is not commonly referred to in the specific case of minerals, it is not likely that the latter are peculiar in this respect. In any case there is abundant evidence of a less exact nature that sulphides especially, do adsorb gases readily and that the gaseous films are extremely difficult to remove.

Whetham ([14]) remarks on "the film of condensed gas which seems to exist on all solid surfaces and to be so difficult to remove." He further refers to the work of Brown, Spiers and Erskine-Murray, on the effect of such films on the potential difference at the surfaces of metals and electrolytes. "Erskine-Murray has shown that the potential is increased by polishing and reduced by oxidation.' Whetham concludes "that there would certainly be less affinity between a gas and a partially oxidised metal than between a gas and a clean metal."

Harkins ([4]) states "Since the flotation process depends on the preferential wetting and adhesion of gas films to metals and sulphides on the one hand and silica and similar substances on the other . . . . "

Langmuir ([1]) refers to the adsorption of gases on solids in connection with the theory that such adsorbed films are in a form of chemical combination with the atoms of the solid surfaces.

Taggart and Beach ([9]) refer to the density of gas layers adhering to solids.

In view of such statements as these and many others, it is impossible to dismiss the phenomena as being of minor importance in flotation.

There are several empirical facts of more direct interest to be recorded with reference to this question.

Mickle ([15]) noted the remarkable pertinacity with which gas adheres to certain minerals. He recorded how zinc and lead sulphides could be made to continue to float by simply heating in water. He assumes that the gas in this case is air and that at each boiling fresh air films are obtained at the surface. Mickle also records similar observations in the case of CO_2 derived from the action of dilute acid solutions on ore particles containing carbonates. He notes particularly the effect of heat on the flotation of sulphide particles by means of CO_2 bubbles. Mickle's work was carried out on zinc and lead sulphides; I have confirmed his results

frequently on ore samples from the Murchison Range district, of the Transvaal, and on Rhodesian gold ores containing antimony sulphide and arsenical pyrite. These investigations are of course based on the well-known Potter-Delprat flotation process. If the slightly acid solution in which a mass or froth of sulphide particles has been floated, is allowed to cool, much of the froth will break up and the particles will sink; on heating again the froth will be reformed. In the case of CO_2 bubbles this can be repeated almost indefinitely although at each heating one notices a tendency for the froth to become less stable. In the case of air the froth formation is not nearly so permanent, and usually with two or three boilings, wetting appears to be complete. It is difficult to interpret such observations unless we assume that even after repeated boiling there are still adherent films of CO_2 gas. It is possible that after heating and cooling several times, the bubbles which attach themselves to the sulphide particles consist chiefly of water vapour. As a result of numerous observations on antimonial ores, however, I am inclined to think that the efficacy of the Potter-Delprat method is chiefly due to the fact that, at or near boiling point, the gas bubbles are given off in just the right condition for successful flotation—that is—as a continuous stream of innumerable bubbles of minute size, providing a relatively enormous surface and not rising too quickly through the liquid.

Henderson [17], in a paper on flotation at Broken Hill, refers to some recent methods of differential flotation devised by Bradford. These methods have a direct bearing on the question of gas adsorption at sulphide surfaces. It is claimed that by generating such soluble gases as hydrogen sulphide and sulphur dioxide at the mineral surfaces, air films, which are assumed to be adhering, are selectively removed so that, by small alterations in the acidity and temperature of the liquid, selective flotation can be carried out. It is stated that these methods are commercially successful and they serve to emphasise the importance of gas films in the theory of flotation. In some experiments on the flotation of stibnite ores by CO_2 bubbles, I have found that by passing large air bubbles into the mixture the floating mass of sulphide particles is broken up and the particles readily sink; on heating again the flotation takes place as before, so it is assumed that the effect of the air is chiefly mechanical. According to Freundlich [8] (p. 98) the nature of the gas is of more importance in determining the amount of adsorption which will take place than the nature of the solid. This is not altogether in agreement with such evidence as is available in flotation investigations, but it may be remarked that Freundlich's statement is apparently based on experimental results on such porous solids as charcoal, meerschaum, etc. The fact that carbon dioxide is more difficult to remove than air is however in accordance with Freundlich's statement (p. 96), that the more easily liquified gases are more strongly adsorbed.

Froths and the effect of oil.—This phase of the subject has been dealt with very fully by several writers on flotation theory including Rickard [15], Hildebrandt [18], Taggart and Beach [9], and notably Sulman [10]. The conditions for a stable froth are clearly set out in works on colloidal chemistry. Lord Rayleigh [19] has shown that frothing is always associated with contamination; in fact, in comparison with other features of flotation the stabilising of the froths is thoroughly well understood. It is of special interest to note, as has been done by Sulman and others, that the mineral particles themselves may provide the stabilising conditions; this is what is meant by the term "armouring" of the bubbles. Thus it may be shown in many cases that when only a small proportion of sulphides is present in an ore these may float but be unable to form a coherent froth since there is insufficient "armouring." With an ore sample containing exactly the same constituents, but a larger proportion of sulphides, a comparatively stable froth may be obtained. Sulman states (p. 53) that the surface tension of water is considerably lowered by the presence of mineral particles. If this is correct it may partly explain the fact mentioned by Mickle [15], Henderson [17] and Hoover [20] also confirmed by the writer on stibnite ores [16] that the presence of much slime in flotation without oil gives unsatisfactory results.,

It is well known that it is easy to overdo the addition of what are called "frothers" in flotation and to obtain a "barren" froth (Sulman, Rickard, Corliss and Perkins). The reason generally given is that the surface tension liquid-gas has thereby been so greatly lowered that the wetting tendency is increased. In the discussion on the equilibrium equation, how-

ever, it was shown that wetting power depends on other factors than the surface tension of the liquid, notably the viscosity.

In most of the papers on flotation theory already referred to, the effects of the oil additions are very fully discussed. The main effect, although there is no very definite evidence on the point, is that the oil spreading rapidly over the sulphide surfaces forms films of extreme tenuity, with the result that the characteristic properties of the sulphide surfaces, as far as the adhesion of gas bubbles is concerned, are so greatly enhanced that practical flotation depends chiefly on these small additions of suitable oils. Sulman (p. 71) gives figures showing greatly increased contact angles for oil filmed minerals in 0·7 per cent. sulphuric acid.

Additional bibliography.—Owing to the method on which this summary of flotation literature has been prepared the references on the subject cannot claim to be complete.

For much useful information, both on the theory and practice of flotation, the columns of the Mining and Scientific Press for the the last five or six years should be consulted. Most of the articles which have appeared in that journal are collected in a convenient volume edited by T. A. Rickard ([21]). The books on flotation by Hoover ([20]) and Megraw ([22]) also contain chapters on the theory of the subject. The effort required to follow the voluminous reports of legal proceedings over flotation patents is not likely to yield sufficient reward to make it advisable. For a non-mathematical treatment of surface tension the reader is referred to *Surface Tension and Surface Energy* by R. S. Willows and E. Hatschek. The most noteworthy contribution to flotation theory which has recently appeared is that by H. L. Sulman, which has been several times referred to. His paper contains a vast amount of valuable information and several portions of it are criticised in the discussion which followed.

Truscott ([23]) questions the application of the term "adsorption" to the adhesion of sulphide particles to gas bubbles and the use of the term suspensoids for a mixture of ore particles and water. He questions if there is any fundamental difference between film and froth flotation.

Porter ([24]) criticises Sulman's idea that a zero contact angle is not accompanied by complete wetting and questions the extremely high value for the contact angle water/glass.

Hatschek ([5]) criticises Sulman's statement that complete wetting means a reduction of interfacial tension to zero and points out that far-reaching conclusions are based on very meagre experimental evidence.

It is impossible to summarise satisfactorily this important paper but there are portions not already referred to which should be mentioned. Sulman insists on the importance of "flocculation" in flotation, and states that in order to be floated the mineral must first be "flocculated." Flocculation has been considerably studied in connection with the settlement of "slime"—Free ([25])—but in articles on flotation I have found the term used only in the paper by Corliss and Perkins. The latter, although not very lucid on the matter, apparently conclude that flocculation is harmful in flotation since the aggregates formed may consist of siliceous gangue particles which may float with the sulphides. If Sulman's statements are interpreted correctly, however, the trend in flotation practice is to float preferentially almost any desired mineral by causing it to flocculate; this is to be done by various modifying physical and chemical factors. These ideas are in all probability the result of the wide application of flotation to the treatment of "slime" which is commonly classed as a colloidal solution. The natural inference to be drawn from Sulman's paper is that there are considerable differences in principle between the methods of flotation he chiefly refers to, and what may be called the film flotation of comparatively large particles which, as has already been mentioned, is best accomplished in the absence of "slime." Possibly this theory of flocculation accounts for the fact that the concentrate obtained by the "Minerals Separation" methods seem generally to contain a very high proportion of gangue ([26]). A further important feature of this paper is the reported effect of acidifying the liquid. It is stated that the contact angles are generally lower in acid solutions; from this it would probably follow that the surface tension of water is decreased by the addition of acids. Taggart and Beach confirm this to some extent, but according to Taylor ([27]), also Kaye and Laby ([12]), the effect of the acid is to slightly increase the surface tension of water. The most obvious effects of adding acid, in the writer's experience, are that the sulphide surfaces may be freed from oxide films, (this is particularly noticeable in the case

of banket ore containing pyrite), and that an additional supply of gas bubbles may be provided in cases where carbonates are present.

Concluding remarks.—As a result of the commercial success of flotation, many new facts have been learned empirically regarding the physical and chemical properties of surfaces. Exact experimental data are however required before sound generalities can be established. It seems to the writer that a statement such as the following is, at present, as much as is justifiable. A tendency for such surfaces as those of metals and mineral sulphides to adsorb and retain films of gas or grease to a greater degree than the surfaces of substances such as quartz and silicates is generally indicated. Such adsorption, according to the theory of adsorption in liquids, must be a manifestation of greater surface energy in the case of the former substances. Having obtained such films, the solids must be regarded as contaminated, and we no longer have true contact between the solid and the two fluids; the energy of the solid surface being reduced to a minimum by such adsorption, the surface energy liquid/gas is manifested by a decreased adhesion of the liquid to the solid, with the result that the gas bubbles cling more or less tenaciously to the solid surface. The aggregations or "floccules" of gas and solid particles thus formed may in certain circumstances sink, but in most cases will rise, owing to the great volume of adhering gas.*

*It is assumed here that the surface energy—sulphide/gas—is high, which, according to the equation $\cos\theta = \frac{T_{sg} - T_{sl}}{T_{gl}}$, means that θ is small, *i.e.*, spreading would take place; the argument is that spreading does occur but it is not the water which spreads but gas, oil or grease. According to this idea we ought to write the equation as

$$\cos\theta = \frac{T^1_{sg} - T_{sl}}{T_{lg}}$$

where T^1_{sg} = The surface tension "contaminated sulphide"/gas. Sulman, on the other hand, in his reply to discussion(*Bull. I.M.M.*, Jan, 1920, p 40) states that there are indications that metallic sulphides may be substances of a lower order of surface energy, which would be curious in view of the high surface tension of molten metals. It should be made clear that the paragraph to which this note refers is not intended as an "explanation" of flotation since it refers everything to surface energy, and in the case of solid surfaces "our reasoning on any phenomenon occurring at such boundaries rests purely on inference from parallel cases at liquid—liquid boundaries."—(Willows and Hatschek p. 87).

If it is true that such metallic surfaces have this greater surface energy, such a fact suggests a connection with the fact that metals and sulphides more readily undergo chemical transformation than quartz, silicates and oxides generally.

It is somewhat disheartening to the metallurgist on taking up the study of flotation theory, to find that the obtaining of experimental data is really a matter for the physical laboratory and that the interpretation of results is by no means easy. Hatschek, in discussing Sulman's work, speaks rather sarcastically of the mass of empirical information imparted and the explanations given of the facts. The assembling and reporting of observations of a purely empirical nature must, however, be of great importance in the construction of a general theory. In actual fact the litigation that has taken place over flotation has, amongst other things, demonstrated that even amongst physicists, there is almost complete ignorance as to the real meaning of the phenomena which attend the wetting of a solid by a liquid. Hatschek himself admits this [5] (p. 23), and suggests it may be due to "a lack of any important problems involving a closer knowledge of these factors." The fact is, however, that the importance of a theoretical study of the phenomena concerned, is not by any means confined to flotation. The references to Whetham's "Theory of Solution," and to the article by Cooper and Nutall on "The Theory of Wetting" in connection with dips and insecticides should make this clear.

There are similar problems involved, in the soldering and welding of metals, in the amalgamation and cyaniding of gold and of even more direct interest on the Rand they have an intimate bearing on the difficult questions concerned in the settlement of fine floating dust particles underground [28].

(1) Clerk Maxwell—Capillary Action. *Enclyo. Brit.* 11th Edition, Vol. 5, pp. 261-263.

(2) Poynting and Thomson—*Properties of Matter*, p 140.

(3) E. Edser—*General Physics.*

(4) Langmuir — *Journ. Am. Chem. Soc.*, 1916. and *Met. and Chem.*, Eng., Oct. 15, 1916: also McLewis—*The Chem. Theory and Capillarity, Science Progress*, April, 1918. Harkins—*Proc. Nat. Acad. of Sciences*, December, 1919.

(5) E. Hatschek in discussion on Sulman's Contribution to the Theory of Flotation, *Bulletin, I.M.M.*, January, 1920

(6) O. C. Ralston—*Min. and Sci. Press*, October 23, 1915.

(7) H. P. Corliss and C. L. Perkins—*Journ. Ind. and Eng. Chem.*, May, 1919.
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(12) Kaye and Laby—*Physical and Chemical Constants.*
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(14) Whetham—*Theory of Solution*, pp. 269-272.
(15) K. Mickle—*Eng. and Min. Journ.*, Aug., 1911 and July, 1912.
(16) H. R. Adam—*Jour. C.M. and M.S. of S.A.*, June 1915
(17) E. Henderson—*Min. and Sci. Press*, Sept., 21 and 28, 1918.
(18) Hildebrandt—*Min and Sci. Press*, July 29, 1916.
(19) Lord Rayleigh—*Lecture on Foam*, *Proc. Royal Inst.*, March, 1890.
(20) Hoover—*Concentrating Ores by Flotation.*
(21) T. A. Rickard—*The Flotation Process.*
(22) Megraw—*The Flotation Process.*
(23) J. A. Truscott—*Bulletin, I.M.M.*, Dec., 1919
(24) A. W. Porter—*Bulletin, I.M.M.*, Jan., 1920.
(25) E. E. Free—*Eng. and Min. Journ.*, Feb. 5, 1916.
(26) Report on legal proceedings over flotation—*Min. and Sci. Press*, Sept. 29, 1917.
(27) W. W. Taylor—*The Chemistry of Colloids*, p. 237.
(28) J. Moir—Recent Investigations on Dust in Mine Air, *Jour. C. M. and M.S. of S.A.*, July, 1915.

THE GOLD PREMIUM.

By S. Evans (Associate).

(Printed in Journal, May, 1920).

DISCUSSION.

Prof. Edwin Cannan, Professor of Political Economy at the University of London *(Contributed)*: It is difficult to make out exactly what is thought at such a distance, but as far as I can judge from the literature which has reached me, there is some considerable haziness in South Africa about the root cause of the present decline in the profitableness of gold mining.

I do not see myself why there should be the least doubt that the decline is due to the diminished real value of gold, that is, to its diminished power to buy commodities and services. All over the world, whether gold or silver or some depreciated paper currency is the actual standard in which prices of goods and services are reckoned, a man with an income of 100 or any other given number of ounces of gold is a much poorer man than he would have been before the war. In most countries, it is true, he can sell his gold for more money—more pounds sterling, more francs, more marks—than he could before the war, but the greater quantity of money has a smaller purchasing power, so that when he lays it out he finds that he has got far less of the commodities and services which he wishes to buy. Things have not yet settled down sufficiently to make the decline of purchasing power quite uniform, but the average for the world at large is probably in the neighbourhood of fifty per cent. This is common knowledge.

Now how can it be doubted that this diminution must be bad for the gold-mining industry. The only wonder is that its condition is not worse than it is. What would have happened to coal mining or to iron ore production if the purchasing power of coal or iron had fallen to one-half? Obviously many sources of coal and iron would have become impossible to work at a profit, and the profits of those which remained would have been greatly reduced. By making a very "poor mouth" the producers of a thing which has fallen in value may induce the persons from whom they buy machinery and labour to sacrifice something, but the competition of other industries will prevent this assistance from being important and lasting. Gold-producers are no exception to the rule, and when the value of gold falls they will have to give away more of it in payment for the machinery and labour which they require for their business. No premium on gold can mend matters, since the existence of a premium only means that the pound sterling, or the franc or mark or whatever the unit of currency may be has lost its purchasing power even more than gold has done. When the paper pound sterling is worth only 3·89 American gold dollars instead of the par of 4·87, the gold-producer will get a premium of 25 per cent. if he sells for English pounds and none if he sells for American dollars, but the pounds which he gets will be worth precisely the same as the dollars. If gold-producers in America have so far suffered rather more from the decline in the purchasing power of gold than those in South Africa, this is a merely temporary phenomenon, due to American gold mining being more quickly affected by the competition of other industries than gold mining in South Africa. It is certainly not due to the South Africans having been paid

a premium which only makes the whole price which they get equal to that which the Americans get. The real question is how much machinery and labour an ounce of gold will buy.

The cause of the diminution in the purchasing power of gold is pretty obvious. It is to be found in the fact that many great and important countries under the stress of the war discarded gold to a prodigious extent. Instead of continuing to take their usual proportion of the annual production of new gold in order to maintain and add to their currencies, their ornaments, their dental plates and other things, they not only stopped that demand altogether, but even sold a considerable part of their pre-war stock of gold to neutral countries and to belligerents less pressed by the war than themselves, taking in exchange things of more direct use in warfare. Since the Armistice I dare say there has been some revival of the European ex-belligerents' demand for gold for industrial purposes, but it is safe to say that they have not imported a single ounce for currency purposes. There has been a little shifting—Germany has had to part with twelve million ounces—but certainly no increase in the aggregate of their gold stocks. If the same kind of thing had happened to any other metal—if, that is, the demand for it had fallen off to the same extent, does anyone doubt that its power to purchase other commodities and services would not have enormously declined? "The rest of the world," it may be thoughtlessly said, "has shown no reluctance to take the whole production of new gold and also the old stock parted with by the belligerents." Indeed? Why then did the European belligerents have to pay so dearly for their imported articles? The outside world has taken the gold indeed, but only at half price—it has only given half the old quantity of commodities and services for each ounce of gold.

The one hope for the gold industry lies in the possibility of a revival of the demand for hard money in the great European countries. The paper standards which they have substituted are working so badly that it is quite impossible that they can continue very long to be regulated, as they are at present, by the balance between the desire of governments to spend money without raising taxes and their fear of discontent induced by perpetually rising prices. The United Kingdom and perhaps one or two other countries will probably in one way or another restrict their issues until their monetary unit comes up to its old parity with gold, and then the gradual increase of their reserves will re-establish a small demand for gold. It is not very probable that gold coins will come back into ordinary circulation in England, as the people are now used to notes and find them convenient, so that the demand for new gold which used to arise from the abrasion of the coin in circulation may be regarded as definitely lost. Some of the other more solvent countries will probably succeed in fixing a definite ratio between their currency unit and gold, not at the old par but some way below it. So far as the demand for gold is concerned, this is an unimportant detail: whether the old parity is restored or a new one adopted, the same amount of gold reserves will be required, and the active circulation of gold is equally improbable. More hopeful from the point of view of the gold-producers are those countries which seem likely to go on issuing more and more paper money until at last it becomes totally worthless. Experience—the last instance in Mexico—suggests that over-issue of paper money carried to the extreme drives people to transactions in metal and thus re-establishes a demand for metal to increase and maintain the currency. It is sometimes said that the countries with very depreciated paper currencies are too poor to buy gold, but a tolerable currency is a necessary of life, and if a government goes on long providing an intolerable one, its people will manage somehow to provide themselves with a better. It must always be remembered that, as money is accepted in order to be passed away again, it does not strike the individual who has made, say, a pair of boots, as an extravagant action to buy half an ounce of coined gold with boots: on the contrary, he calls it selling the boots for good money and regards it as excellent business. Poverty will neither prevent the emergence of coins from holes in the thatch or in the garden nor prevent the export of goods in exchange for coins which can be obtained from abroad.

The conclusion from this is that a gold-producer lost to all sense of patriotism and humanity and thinking only of his own interest as a gold-producer might wish to see all countries, including his own, issue paper money so rapidly as to bring it into complete disrepute all over the world at an early date, after which his own particular

product would be in bigger demand than ever. But if a good citizen of his own country and of the world at large, he will join other good citizens in hoping that his own country and as many others as possible may keep out of the *débacle*, and be preserved from all the miseries involved in an orgy of paper prices, followed by a slump and a necessary reopening of all contracts. This granted, his wishes will coincide with those of other citizens: he and they will both desire a speedy return by their own country and as many others as possible to the comparative security and stability of a gold standard.

I do not gather that anyone of influence in South Africa wishes £1 to be permanently less in value than the 113 grns. of fine gold which go to make a sovereign. But to-day (July 8, 1920) £1 in London is only worth about 92 grains, while £1 in South Africa is worth nearly 99*. (It may seem odd that a full weight sovereign, containing 113 grains, should pass current in circulation for 21 grains less in England and 14 grains less in South Africa, but this is explained by the fact that melting and exportation are prohibited in both countries, so that the value of the sovereign while inside the countries is forcibly kept down to the value of the paper £1: once get a sovereign out into the non-British world and its value rises to that of its metallic content). The question then arises "Should South Africa, who wishes to restore her £1 eventually to its old value of 113 grains of gold, take the necessary steps to bring it up to that level without regard to the value of the £1 in the United Kingdom, or should she let her £1 down to the level of the United Kingdom £1 pending the recovery of the United Kingdom £1, or finally, should she be content to take a middle course, keeping her £1, as at present, higher than the U.K. £1, but not up to par?"

The arguments in favour of the first of these courses seem to me overwhelming. To bring the value of the South African £1 down from 99 to 92 grains of gold as a preliminary to raising it to 113 seems on the face of it absurd. It requires a further inflation and consequent further rise of all prices in South Africa with all the inconvenience and injustice of that process, only to be followed shortly by all the inconvenience and injustice of an equivalent fall of prices. There is nothing to be gained by it to set against this, so far as the mass of the community are concerned, though a few acute persons and possibly the banks may manage to make money out of both the rise and fall of prices by a timely transfer of their activities from one direction to the other. It seems to be supposed in some quarters that the person who wants to exchange the right to receive money in London for the right to receive money in South Africa is hurt by the fact that he only gets £93 in South Africa in exchange for his £100 in London, but if the exchange were levelled by further inflation of the South African currency, the £100 (less commission) which he would get would buy him no more of commodities and services than he can get at present for £93, so that he would not be at all better off.

The middle course, which means inaction till the United Kingdom deflates its currency sufficiently to bring the U.K. £1 up to the value of the South African £1, is not nearly so pernicious as the policy of dragging down the S.A. currency to the level of the U.K. currency, but there are grave objections to it. South Africa, as by far the largest producer of gold, has a heavy interest in keeping up a good price for that article in the world at large. The prudent leather merchant has always been credited with believing that there is "nothing like leather," and South Africa in her own interest should cultivate both by precept and example the doctrine that there is "nothing like gold." For her to discard the gold standard by enlarging her paper currency till she depreciated in value of her £1 from 113 grains to 99, much resembles the action of the bootmaker who declared that boots were unhealthy, and ostentatiously walked to his shop in cheap, though perhaps not very durable, sandals.

Not only is South Africa setting an example of a course of action which it is to her interest that the world should not adopt; she also involves herself in grave inconveniences from which European countries adopting it have been exempt. In Europe everywhere depreciated paper has

* I am not clear whether the market for uncoined gold is sufficiently free in South Africa to allow this value to be apparent there. It is quite obvious in London, where the United Kingdom £1 will buy 92 grains, and the South African £1 is worth 7% more than the United Kingdom £1.

been quite readily accepted down to the present time: the most obvious and continuous fall in its value has not as yet led people to ask for payment in gold. In South Africa, on the other hand, I understand there are important elements in the population which display a wholesome distrust of paper. In consequence gold cannot be wholly removed from the circulation as in Europe. This would not matter much if the South African Government had as effective a control over exports of gold as is possessed by the Government of the British Islands: there is very little leakage of gold coins from the United Kingdom at present when anyone with a £1 note can get a sovereign from the Bank of England, and there would probably be only a trifling increase if much of the coin in the Bank was actually in circulation. But owing to the geographical and racial position of South Africa the smuggling out of sovereigns there cannot be kept within small bounds. To provide coins with 113 grains of gold in them and keep a sufficiency of them in circulation as only equal to notes worth considerably less than 113 grains, is certain to be a very expensive and will probably prove an impossible task.

I conclude therefore that South Africa in her own interest and in that of the British Empire and the world at large, should return to the gold standard as quickly as may be. To effect the return nothing appears to be necessary beyond a removal of the prohibition of the export of gold coin. To remove the prohibition without reasonable notice would of course be quite improper and might cause a disastrous crash. Less than twelve months' notice, would, I should imagine, be unreasonable, and possibly a longer period would be required: it would be much better to fix a long period than a period so short that hopes would be entertained by parties opposed to the policy that it would have to be lengthened.

If the prohibition were removed without notice, the demand for coin for export would be so great that the banks would not be able to cash the notes for which payment in gold would be demanded. But if reasonable notice is given and it is believed that the thing will really come to pass, the banks will prepare for it by so ordering their affairs generally and their note-issues in particular, that there will no more be a run on them for gold than there was upon the Bank of England when she resumed meeting her obligations in gold after the long suspension of 1797 to 1821.

Mr. D. M. Mason, London Chairman of the Executive Committee of the Sound Currency Association *(Contributed)*: The advantages to be derived from, and the pressing necessity for, a restoration of an effective gold standard in stabilising the currencies of the various countries of the world, and as a means to give stability to the exchanges are so self-evident, as to require little or nothing to be said or written in support of them. Nevertheless the problem is not so easy of settlement or adjustment as would at first sight appear. In the Napoleonic war period the Bank of England suspended gold payments in 1797 and did not fully resume gold payments until 1822, a period of 25 years. I do not anticipate anything like this duration of time will be necessary before the present embargo or prohibition of the export of gold will have been removed in this country. The greater knowledge which bankers and traders possess, and also many of those in authority, and the improved methods of banking and facilities of exchange which we enjoy to-day, as compared with our forefathers of a hundred years ago, all point to an early and prompt settlement of this most important reform. In spite of this increased knowledge, there are still many who are apparently woefully ignorant of the rules and principles of political economy. For example there is a considerable controversy going on at the present time as to the advantages or the reverse of a dear or cheap money market. One would imagine that it was a matter of convenience and that dear money or cheap money could be turned on or off like a water tap at will. It is true that with an inconvertible paper currency, by recourse to the printing press a plentiful supply of cheap money can be provided, but at a serious cost to the community. Such a course of action leads to an artificial prosperity, extravagance among all classes, derangement of the foreign exchanges, and a general rise in the prices of all commodities. What then is or ought to be the governing factor which should determine the price of money? Surely it is the proportion which the floating or loanable capital of the world bears to the fixed or funded capital. During the past five years there has been a steady transference of floating or loanable capital into fixed capital. There has also been a large destruction of capital. Therefore loanable capital, or money which represents capital ought to be and is very scarce and dear. Of course, as I have already stated, cheap money or

credit can be manufactured, but we know at what cost to the general community. It is therefore clear that if we desire to realise the position in which we stand to-day, we must face the situation and flee all inflation, embargoes, subsidies, and other devices which hide the real situation as we would the devil himself, and endeavour to balance our national balance sheet in the only way it can honestly be balanced, by living within our national income. To enable us to achieve this end, I suggest that the temptation to have recourse to the printing press should be withdrawn. In other words every effort should be made to re-establish our currency upon a sound basis by a return to an effective gold standard. When this has been accomplished the prohibition of the melting of gold for export can be removed. If the convertibility of the Treasury Currency Note is assured it will automatically put a stop to excessive issues and check the prevailing evils of a redundant and depreciated currency. This reform can best be brought about by a gradual contraction of the issue outstanding. If a policy of economy is rigidly pursued loanable capital will accumulate, and a money market with plenty of capital seeking investment will again come into view, with the usual accompaniment of trade expansion and development throughout the world.

If proof is required that the currency is depreciated I would point to the state of the foreign exchanges and to the test applied by Ricardo which was confirmed in the famous Bullion Committee's report, *i.e.*, "That the price of gold bullion can never exceed the Mint price, unless the currency in which it is paid is depreciated below the value of gold." The Mint price is £3 17s. 10½d. per oz. of standard fineness, and the market price is about £5 per oz. The difference between these two prices is approximately the measure of the depreciation of the currency which now exists.

When the old rates of exchange have again been stabilised with the United States of America, and other countries which have maintained a gold standard, it is reasonable to anticipate that countries with still more depreciated currencies will also take the necessary steps to stabilise them in relation to gold, thus causing a gradual return of steadiness to international trade.

According to an "Economist" table the total of paper money issued by the belligerents and the principal countries of the world before the war amounted to £1,535,000,000. At the end of 1918 this total had risen to £21,727,000,000. Where the issues have been greatest the rise in prices has been greatest, *i.e.*, in Russia, Germany and France. All countries have been affected including the United States of America. Of course this is not the only factor in bringing about a rise in prices. The war itself in withdrawing men and women from industry and the large destruction of property coinciding with a steady production of gold (although this last now shows a declension) have all contributed to a rise in the gold prices of commodities. No one expects that prices are likely for many years to come to go back to pre-war levels, but if paper prices and gold prices can be brought back to equilibrium and stability given to the exchanges a tremendous impetus will be given to the trade and commerce of the world.

Some people say that all that is required is increased production and that increased exports will remedy the adverse exchanges. If we go back to the Napoleonic war period we find the same arguments advanced to cure the same evils, and men like Ricardo pointing out that although the customs returns were favourable, the rate of exchange still remained adverse, and showed therefore that there was some other cause at work. That cause was then, and is now, the depreciated condition of the currency. It is true that an adverse exchange for the time being indirectly helps the British exporter by enabling, for example, the American importer to purchase his sterling draft at a lower figure than he otherwise would do to pay for his imports. But on the other hand an adverse exchange penalises the British manufacturer by compelling him to pay an additional amount of British money for his imports of raw material from America. This in the long run does harm to all trade and industry by increasing the cost of production.

The advantages, therefore, of bringing about stability in the foreign exchanges are self-evident and the object of the Sound Currency Association is to hasten that state of affairs. The Association recognises that this cannot be done in a day, and that reform can only come gradually. It suggests a gradual reduction in the amount of paper

money outstanding until the gold premium has disappeared. This can more easily be achieved through a policy of peace abroad, drastic economy in every department of the State, and reform where practicable and within the means at our disposal.

The Secretary.

The Secretary, Capt. H. A. G. Jeffreys, O.B.E., has been notified by the Secretary to the Governor-General, to the effect that His Excellency has been advised by the Secretary of State for the Colonies that His Majesty the King has given unrestricted permission for the wearing by him of the decoration of Chevalier, Ordre de la Couronne, conferred upon him by His Majesty the King of the Belgians.

This decoration has been granted in recognition of services rendered by Capt. Jeffreys in connection with the adjustment of financial accounts between the British and Belgian Forces in East Africa.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Magnesite. — "The Imperial Institute reported upon a sample of South African magnesite, which, it states, compares very favourably in composition with Grecian magnesite, except in the proportion of silica present. The analytical figures obtained were.—MgO 45·65%, CaO 0·63%, Fe_2O_3 0·22%, Al_2O_3, 0·13%, SiO_2 3·27%; CO_2 50·%. The best commercial magnesite from Greece contains about 1·5% of silica, and the poorer qualities about 2·5."—(*S. Afr. J. Ind.*, Jan., 1919.) *Journ. Soc. Chem. Ind.*, *April* 30, 1919, 143R. (J. A .W.)

Rapid Determination of Silver in Cyanide Solution.—The silver is precipitated from 10 or 20 A.T. of the solution by means of zinc dust and lead acetate (10 ccs. lead acetate, 5 grams zinc dust and 25 cc of 50% by volume sulphuric acid).

The precipitate is washed by decantation dissolved in nitric acid, the red fumes boiled off. The solution thus prepared is titrated with standard potassium thiocyanate. The thiocyanate is standardised with standard silver nitrate solution.—J. E. Clennell, *Eng and Min. Journal*, Nov. 8, 1919, p. 785. (H. A. W.)

Errors in the Analysis of Chromite and a New Process.—"Tests with synthetic mixtures containing known quantities of chronium showed that by the usual methods—fusion with sodium peroxide, alkali carbonates and nitrate, or potassium bisulphate—errors, generally minus, amounting to 10% of the quantity of chromium present are quite possible. By the following modification of the sodium peroxide fusion method the quantity of chromium found averaged 99·6% of that present, with a total variation of about 1%:—The finely-ground chromite is gently heated with 6—8 times its weight of sodium peroxide, in a thick, deep, iron crucible, until the initial effervescence ceases, and the melt is then maintained at low redness for 10 mins. (being agitated by rotation meanwhile), cooled and extracted with water. After the addition of sufficient sulphuric acid (20%) to effect complete solution, 2 gm. of potassium persulphate or 3—5 gm. of ammonium persulphate is added to the liquid, which is then heated, at first rapidly to 80° C. and then slowly to boiling. The excess of persulphate is removed by diluting the liquid with liquid with about 25% of its bulk of sulpharic acid (20%) and boiling for 30 mins., and the solution is then cooled, diluted, and titrated with excess of standard ferrous ammonium sulphate followed by potassium permanganate. A marked red-brown colour in the final solution indicates the presence of permanganic acid (from manganiferous ore); it is discharged before titration by the addition of 2 drops of concentrated hydrochloric acid or about 1 mgm. of benozic acid to the nearly boiling liquid."—J. Moir.—*Original Journal* J.S.A. Assn. Analytical Chemists. Jan. 1919. 2.—*Journ. Soc. Chem. Ind.*, April 30, 1919, p. 260A. (A. W.)

Laboratory Apparatus for Evaporation.—"Evaporation of liquids in basins on a steam-bath is accelerated by a blast of air, which is first passed through a screw-capped brass cylinder, 3 cm. by 15 cm., packed with cotton to act as a filter, and then through a heating coil of copper tube 2 m. by 0·6 cm., which rests upon the steam pipes in the bath, and has its outlet raised above the bath, and connected by means of rubber tubing with a series of nozzles. Each of these is provided with a glass stop-cock, and is supported by a bent wire which slides within a hollow standard, thus enabling the height of the nozzle above the bath to be adjusted. The air issuing from the nozzle is at about 60° C. By its use water can be evaporated in less than half the usual time, and 95% alcohol in about one-sixth of the time. The apparatus is also useful for the rapid evaporation at low temperatures of substances which readily volatilise or polymerise at higher temperatures."—E. C. Merrill and C. O. Ewing.—*J. Ind. Eng. Chem.*, 1919, *11*, 230.—*Journ. Soc. Chem. Ind.*, April 30, 1919, p. 269A. (J. A. W.)

Low Temperature Carbonisation, etc.—"The author considers that the maximum utilisation of the material and energy of raw coal would be achieved by low-temperature carbonisation of the coal with recovery of the liquid products and a portion of the ammonia, gasification of the resulting coke with further recovery of ammonia, and conversion of the producer gas into electrical power. The ash residue could be employed for brick making, etc. The high-temperature carbonisation of a ton of coal at 2000°—2200° F. (1090°—1200° C.) yields 12,000—13,000 cub. ft. of gas of calorific value 500 B.Th.U., 66% of coke residue, 9—10 gallons of tar, and 20 to 28 lb. of ammonium sulphate. Low-temperature carbonisation at 900°—1000° F. (480°—540° C.) results in the production, per ton of coal, of 4000—6000 cub. ft. of gas of calorific value 650 B.Th.U., 70—75% of coke

residue, 18—22 gallons of tar oils, and 15—22 lb. of ammonium sulphate. Low-temperature coke obtained by carbonising in Tozer retorts (J. S. C. I. 1914, 912) is not friable and moreover a high yield of ammonia is obtained by its gasification. The volatile content of the coke varies from 9 to 12 %, the calorific value being 13,300 B.Th.U. per lb. By stripping the gas produced by the low-temperature carbonisation, 1½—4 gallons of an oil of the nature of motor spirit (sp. gr. 0·760—0·800) is obtained per ton of coal. The oils possess the properties of paraffins. Results are tabulated of the yields of the various products obtained by the carbonisation at temperatures below 1200° F. (650° C.) of 21 samples of different coals. The various fractions of the tar oils possess properties rendering them useful as motor spirit, fuel, oil, and lubricants respectively. Naphthalene and anthracene are absent. The pitch is characterised by its plasticity and low percentage of free carbon. The Tozer low-temperature retort (*loc. cit.*), in which coal is carbonised in a number of concentric annular iron segments enclosing a central gas way, is described."—*Gas J.*, 1919, *145*, 383. F. D. Marshall.—*Journ. Soc. Chem. Ind.*, April 15, 1919, p. 212A. (J. A. W.)

O-Tolidine as a Colorimetric Test for Gold.—"One part of gold (as gold chloride) in 1 million parts of water gives a bright yellow coloration when treated with a 0·1% o-tolidine solution in 10% hydrochloric acid; with a solution containing 1 part of gold in 20 million the yellow coloration can just be detected in a depth of 10 cm. of liquid. Ferric salts, ruthenium, osmic acid, and vanadic acid also give a yellow coloration with the reagent, but the following metals, when present as chlorides, do not react:—Aluminium, antimony, barium, bismuth, cadmium, calcium, chromium, cobalt, copper, iridium, lead, magnesium, mercury, manganese, nickel, platinum, rhodium, sodium, strontium, tin, uranium, and zinc. The solution to be tested should be free from nitrous acid and reducing substances. If copper is present a green coloration is obtained instead of pure yellow."—W. B. Pollard.—*Analyst*, 1919, *44*, 94.—*Journ. Soc. Chem. Ind.*, April 30, 1919, p. 269A. (A. W.)

Determination of Nitrous Acid and Nitrites.—The volumetric methods described in the literature for the estimation of nitrites are unsatisfactory. The following method gives reliable results. The nitrite solution is run into an excess of standard permanaganate acidified with sulphuric acid (1 : 4), with constant shaking. The excess permanganate is reduced by the addition of an excess of standard ferrous sulphate, sodium oxalate, or hydrogen peroxide, and the excess of reducing agent titrated with potassium permanganate. The estimation is not affected by moderate amounts of chloride or small amounts of bromide. Silver nitrite is not a satisfactory material for use as a standard in nitrite estimations. Sodium nitrite solution titrated with potassium permanaganate by the method described above is a satisfactory standard solution, or sodium nitrite solution may be standardised gravimetrically by the reduction of silver bromate to silver bromide by Busvold's method. J. S. Laird and T. C. Simpson, *Journ. Soc. Chem. Ind.*, June, 16, 1919, p. 3[illegible] A. (J. A. W.)

Magnesium.—"The production of magnesium on a commercial scale started in 1915 as a result of supplies from Germany being cut off, and to meet the greatly increased demand for the metal for war materials. In 1915 the output of the three producing firms was 40 tons of magnesium with an average selling price of 20s. per lb.; in 1917 five firms produced 51 tons of the metal with an average selling price of only 8s. 4d. per lb., but two of these ceased to manufacture on account of the low price. The pre-war price of the imported metal was 6s. 10d. per lb. Most of the magnesium produced in the United States is made from magnesium chloride residue (bittern) from the salt brines at Midland, Mich., from magnesite and dolomite from California and from Grenville, Quebec. A probable future source is San Francisco Bay, Cal., where almost inexhaustible supplies of suitable magnesium compounds are available. Magnesium is cast into rods 14—18 in. long and ⅜—2 in diameter and is drawn into wire. The powdered material must pass through No 200 screen in order that it may burn rapidly. The chief uses at present are (*a*) flashlights; (*b*) chemical reagents; (*c*) the ignition of thermite charges; (*d*) as a deoxidising agent; (*e*) as a constituent of alloys particularly in association with 8% of aluminium, which produces a metal of sp. gr. 1·75 with a strength equal to that of gun metal. Another aluminium-magnesium alloy containing only 2% of magnesium (magnolium) is used for making forks, spoons, etc., and, generally, where a light, white metal is required; (*f*) as a dehydrating agent; (*g*) for cathodes in the electrolysis of neutral or alkaline solutions free from heavy metals, and in the electrolysis of alkali chlorides. Magnesium anodes are used for producing galvanoplastic deposits of nickel and cobalt. It is considered probable that magnesium will shortly be used as extensively as aluminium."—(*U. S. Geol. Surv.* Dec., 1918.)—*Journ. Soc. Chem. Ind.*, April 15, 1919, p. 126R. (J A. W.)

METALLURGY.

Leaching Roasted Copper Ores.—An improvement in the process of leaching roasted ores is being demonstrated in Vancouver by Mr. C. J. A. Dalziel. The ore particles are agitated in sulphuric acid solution by jets of air. The copper is dissolved out in 24 hours, and the clear solution is siphoned off directly into electrolytic cells.—*J.S.C.I.*, May 31st, p. 185 R. (A. W.)

High Speed Steels.—At the recent meeting of the American Steel Treaters' Society, Mr. Roy C. McKenna, of the Vanadium Steel Company, gave a brief sketch of the methods used in the manufacture of high-speed steels. On the whole he thought that a better product could be produced in the electric furnace than in the crucible. The average chemical composition was given as:—Tungsten, 16 to 20; chromium, 3½ to 5; vanadium, ½ to 1½; carbon, 0·62 to 0·77; sulphur and phosphorus, 0·02 to 0·77; sulphur and phosphorus, 0·02 to 0·025 per cent. The presence of traces of manganese and silicon was not considered of any consequence, but copper and arsenic were not to be allowed under any circumstances. The physical treatment of the steel in rolling into bars was considered of fundamental importance, and because of this Mr. McKenna believed that the steel consumer should

mainly depend on the producer in the matter of specifications and adapt himself to the brands of steel offered, which the producer offered in a reasonable variety.—R. C. McKenna, *Iron and Coal Trades' Review*, January 2, 1920, p. 30. (J. A. W.)

Stellite and Stainless Steel. — "In 1899 the author produced an alloy consisting of practically pure nickel and pure chromium by heating their mixed oxides with aluminium. This alloy, when polished, retained its lustre, even in the atmosphere of a chemical laboratory, and proved to be practically insoluble in nitric acid, even when boiling. It is malleable when cold, and under proper annealing can be worked into sheets and wire. Shortly afterwards an alloy of cobalt and chromium was produced, which not only showed the same untarnishable properties as the nickel-chrome alloy, but possessed much greater hardness. The alloy could not be worked to any extent cold, but was found to be malleable at a bright orange heat. In 1909 a cutting blade was made of the alloy, which took an edge comparable to that of tempered steel. Later, tungsten or molybdenum was added, and the alloy thus produced was sufficiently hard to turn iron and steel on the lathe. Later experiments demonstrated that such alloys when properly formed would scratch any steel, and would stand up under much higher speeds on the lathe than the best high-speed steel tools.

Generally speaking, the cobalt-chromium alloys possess three distinctive properties, namely :—(1) They are untarnishable under all atmospheric conditions, and immune to nearly all chemical reagents. (2) They possess great hardness. (3) They retain their hardness up to visible redness. Some of the stellite articles for ordinary use are formed from alloys of cobalt and chromium only. This alloy answers well for table knives, spoons, etc. The harder edge tools, such as pocket-knives, surgical instruments, etc., contain in addition to cobalt and chromium a certain amount of tungsten to give them greater hardness, while in other instances a certain amount of iron is introduced into the alloy to soften it so that it may be more readily worked. Such articles include table-knife blades, pocket-knife handles, certain dental instruments, etc. When iron is added to the alloy the resulting mixture is termed 'Festel metal.' This beautiful and easily workable alloy is well adapted to the manufacture of fine door latches, door-knobs, and high class sanitary fittings for bath-rooms, lavatories, etc. It is not malleable except at a bright red heat, but when a certain portion of nickel is added it may be worked cold on the lathe or under the file.

Some of the later stellite alloys have shown most remarkable resistance to chemical reagents. One of these, possessing quite high chromium, takes a magnificent polish, resembling that of burnished silver. This alloy retains its lustre perfectly in boiling *aqua regia*, and is not affected in the slightest degree after immersion in that liquid for a period of 14 days. It is slowly attacked by cold hydrochloric acid, but is practically immune to cold, strong sulphuric acid, and nearly immune to the same acid in the diluted form. It is, of course, strictly immune to nitric acid of all strengths. Balance weights made of this material retain their lustre under the most trying conditions. There seems to be no good reason why they would not answer equally well as the more expensive platino-iridium alloys for standard weights and measures.

Numerous metals may be added to stainless or rustless steel, and some of these may contribute slight benefit, while others may be slightly detrimental. Among these are nickel, cobalt, vanadium, silicon, boron, tungsten, molybdenum, titanium, and tantalum. It is evident that an indefinite number of alloys could be thus formed, some with and some without the above elements, but none would be stainless unless it contained the proper amount of chromium, which is the essential element to be added to nickel, cobalt, or iron to produce a stainless alloy.

About two or three years after the author's discoveries recorded above, Mr. Harry Brearley, of Sheffield, discovered practically the same properties in chrome-steel independently of the author. Mr. Brearley filed an application, and the U.S. Patent Office granted a patent to him. Mr. Haynes' first application for a patent was refused, but on a second application in May, 1919, practically all his claims were granted by the U.S. Patent Office. A personal service corporation was formed in the States, to which both the Haynes and Brearley patents were assigned, and licences have now been granted to the principal steel makers for the manufacture of stainless steel under these patents. The Corporation is the American Stainless Steel Company, with offices in Pittsburgh.

Stainless or rustless steel consists essentially of an alloy of iron and chromium, containing usually from 0·1 to 1% of carbon, though the latter element may be present up to nearly 2% without interfering seriously with the working qualities of the steel. Owing to the high percentage of chromium and its tendency to oxidise at the melting point, even in the presence of carbon, it has been found advisable to melt the steel either in crucibles or in the electric furnace. After melting the metal may be poured into ingot moulds in the usual manner, and the ingots thus obtained may be forged or rolled into bars or sheets. If the ingots are of comparatively small size they will be found to be very hard after casting, especially if they have been stripped hot and allowed to cool rather rapidly in the air. Indeed, small bars thus produced are likely to be almost file-hard. If a small piece of the steel thus produced and a piece of ordinary steel are placed in a beaker and covered with nitric acid, the ordinary carbon steel will be dissolved with great violence while the chrome-steel will remain utterly unchanged. This is true whether the steel contains carbon in large or only minute quantities.

Cold chisels cast in iron or graphite ingot moulds are sufficiently hard, without tempering, to cut ordinary iron or steel. By heating cast bars to a bright orange temperature they can be forged pretty readily into various forms. After the forging is completed, the metal may be allowed to cool in the air, and will be found to possess remarkably fine grain and good cutting qualities. Quenching in water enhances the hardness to a considerable degree, particularly if the steel contains more than 0·4% carbon. It is best, however, to use oil for quenching, in order to avoid local contraction stress in the finished article. Notwithstanding the comparatively high temperature of working this steel, the bars show almost no scale during forging, and when finished are covered with a blue-black 'skin' consisting of a thin film of oxide.

Owing to the absence of deep oxidation and resistance to deformation at comparatively high temperatures, the alloy is admirably suited for cast engine valves and distilling apparatus, and for many other purposes of like nature. When ground and polished the alloy resists tarnish to a remarkable degree. It is superior in this respect to brass, copper, and nickel plate, and far superior to any other steel yet produced. Axes, hatchets, saws, or chisels made from it not only will not rust in the atmosphere, but are unchanged when exposed to salt water or salt air. It should find a large use in the manufacture of propeller blades for vessels, since its modulus of elasticity is much higher than that of bronze, and it resists the action of both fresh and salt water perfectly. Its great strength and comparatively high elastic limit are likewise in its favour. It will doubtless also have a large application in the manufacture of pump-rods, cylinder linings, pump valves, etc.

Answering a query in the course of the discussion, the author stated that the tensile strength of stellite was perhaps a maximum of 160,000 lb. per sq. in., with a fair elongation, varying with the treatment, from 6 to 8%, and the reduction in area of a 'bar of that kind' would not be over 6 to 8%. It is not very marked. Sometimes it breaks off without reduction, owing to a strain in tempering, perhaps at the point of rupture. That is a question of heat treatment."—E. HAYNES. *Iron and Coal Trades Review*, April 30, 1920, p. 596. (J. A. W.)

MINING.

CONTROL OF ATMOSPHERIC CONDITIONS IN HOT AND DEEP MINES.—*First Report of the Committee.*—In the present report we propose to make a preliminary general survey of the investigation, and to indicate the lines on which we are working and the detailed points on which information is being collected. Although the human body temperature is extremely steady at about 98 deg. to 99 deg. Fahr. and any abnormality in its causes symptoms of illness, it is well known that men can live in perfect health at air temperatures varying from considerably below zero Fahr. to 120 deg. more; and probably no animal or living organism of any kind can withstand great variations of external temperature, and, at the same time, retain its physiological efficiency as well as a man can.

A good deal of experimental investigation remains to be done before the factors, which in actual mining practice limit a man's capacity for normal work, can be defined with precision; but the main facts seem to be fairly clear. Apart from all conscious interference, the living body regulates its internal temperature by several means. The first of these is by regulating the blood flow through the skin. If the temperature of the air is below that of the body, heat is withdrawn from the body by both conduction (including convection) and radiation. The loss by conduction to air tends to vary with the rate of movement and temperature of the air, while the loss by radiation tends to vary with the surrounding temperature. By varying the rate at which blood is circulating through the skin, the body regulates this loss of heat, as in proportion to the cooling of the skin a smaller quantity of cooled blood passes inwards from it, and *vice versa*. It is evident, however, that this means of regulation must fail in a sufficiently warm atmosphere. A further means of regulation depends on the fact that in a cold environment the production of heat within the body tends to be increased by increased muscular activity. But there is a limit to the amount by which the heat production in the body can be diminished. Hence this means of regulating must also fail in a sufficiently warm atmosphere. In warm atmospheres there is a third means of regulation, and this is the most important one in relation to deep and hot mines. As soon as the body temperature tends to rise above normal, there is active secretion of sweat by the skin, and the disappearance of heat in the evaporation of this sweat keeps the skin cool; so that even when the air temperature is far above the body temperature, the latter remains normal if the sweat can evaporate with sufficient freedom.

The physiology and physics of cooling by sweating are of such fundamental importance in relation to the subject of this report as to require somewhat detailed consideration. When water evaporates, the amount of heat which is required for its conversion into vapour, or "latent" heat, is, of course, enormous. For the conversion of 1 kg. or 2·2 lbs. of water at body temperature into aqueous vapour at the same temperature, the heat required is 582 calories, or as much heat as would warm 582 kgs. of water 1 deg. cent., or 5 quarts from freezing-point to boiling-point. A miner working at his full normal capacity m[illegible] produce heat at the average rate of about 250 calories per hour during seven hours' work, as compared with about 70 calories during rest. Hence if the temperature of the air were the same as that of the body, so that he could not lose heat by radiation or conduction, he would require, in order to keep his body temperature normal, to evaporate during the shift about 3 kgs., or nearly 6 pints, or about 1 lb. per hour, of sweat. With a lower temperature the amount of evaporation needed would, of course, be less, as part of the heat, or possibly nearly all of it, would be got rid of by radiation and conduction. Now the body can produce quite easily sweat at the rate of 1 lb. or even 2 lbs. per hour for many hours at a time, provided that sufficient water is drunk. Dr. W. E. Hunt determined recently the average amount of water drunk daily by several healthy Europeans during active outdoor life in India with a shade temperature during the day of about 115 deg., and found that the smallest quantity was 3 gallons, or 30 lbs. Nearly all of this was, of course, lost by sweating. It should be noted that large quantities of sweat may be evaporated without any visible moisture being seen on the skin. In hot and dry climates there is very little visible sweating; and, indeed, it is evident that sweat which drips from the skin without evaporation is wholly wasted. Prof. Osborne, of Melbourne, found that in hot and dry weather in Australia about 1 lb. of sweat per hour may be lost without the skin or clothes being damp. The body carries a large reserve of water in the muscles, so that correspondingly large quantities of sweat can be produced without causing any sensible concentration of the blood; but, after a time, it becomes necessary to drink enough water to replenish the loss; and it is well known that miners in hot mines require a good supply of water. In the hotter Cornish mines each man carries down with him a small cask of water.

So far as mining conditions are concerned, the capacity of the body for sweating to the requisite extent is practically unlimited; but the conditions

for evaporation of sweat may be altogether defective. Consequently, everything turns on these conditions. It is clear that if the air were already saturated with moisture at the body temperature, there could be no evaporation from the skin, so that no heat could be given off. The body would then be defenceless against heat, and, despite profuse sweating, the body temperature would drift upwards. If, however, the air were only saturated to a lower temperature—that is to say, if the "dew-point" were at a lower temperature—evaporation from the skin could still occur; and if both the evaporation and the skin circulation were fast enough, the body could get rid of its superfluous heat. Now the rate of evaporation is practically proportional to the rate at which air passes over the moist skin or clothes. If this air were completely stagnant, the aqueous vapour could only escape outwards by the extremely slow process of gaseous diffusion. On the other hand, unsaturated air not only tends to cool down a moist surface towards the dew-point, but also tends by conduction to warm up the cooled surface towards the air temperature; and unless the air current is very considerable, radiation will also contribute appreciably in this direction. The result is that when there is a sufficient air current to swamp the influence of radiation and conduction through still air, the surface assumes a definite temperature between the air temperature and the dew-point; and when no other source of heat or cold is affecting the surface, this intermediate temperature is known as the "wet-bulb" temperature, as it is the temperature assumed by the bulb of a thermometer kept most with water. The temperature of the moist skin is evidently not the wet-bulb temperature, but something intermediate between the latter and the body temperature, since the body heat is tending to warm the skin. The greater the air current, however, the more nearly will the skin temperature approximate to the wet-bulb temperature if the skin is moist, provided that the heat-flow from the interior of the body to the skin remains constant.

As the web-bulb temperature is the temperature to which a moist surface can be cooled by evaporation in air if the cooling is not hindered, and the wet-bulb temperature may be the same when the air temperature and dew-point are far apart, it is only to be expected that (other things being equal, such as the amount of clothing, the air current, and the production of heat in the body), the effect of warm air in raising the body temperature abnormally will depend on the wet-bulb temperature. That this is actually the case was shown by Haldane, who found by observations in a hot disused level at Dolcoath Mine and in laboratory experiments that if the wet-bulb temperature exceeded 88 deg. in perfectly still air, and during rest, with a minimum of clothing, the body temperature rose continuously, and the faster the higher the wet-bulb temperature. What the air temperature, or the dew-point, or the relative humidity were, did not matter except in so far as they affected the wet-bulb temperature. Thus an air temperature of 133 deg., with the wet-bulb at 88 deg., had no more effect on the body temperature of 88 deg. with the air saturated. At both temperature the body was just able to keep its temperature from rising, and there was profuse sweating; but at 88 deg. most of the sweat failed to evaporate, and was thus wasted. In a further series of experiments at the Doncaster Coal Owners' Laboratory and at Oxford the same observer found that when the wet-bulb temperature was above the body temperature, the rate of rise of body temperature depended also (other things being equal) on the wet-bulb temperature and not on the air temperature. When an air current was present and the wet-bulb temperature was below the body temperature, it required a higher wet-bulb temperature to cause a rise of body temperature, just as might be expected. But with the wet-bulb above the body temperature, an air current accelerated the rise of body temperature; and with the wet-bulb temperature at 120 deg. or more, a painful burning sensation was produced by moving air or by bodily movements which brought more air into contact with the skin. When muscular work was done, the wet-bulb temperature at which the body temperature began to rise was lower, as could be expected in view of the greatly increased heat liberated in the body during work. In other work, continuous hard work was impossible in still air unless the wet-bulb temperature was considerably below 88 deg. Thus, even with the wet-bulb temperature at 78 deg. continuous fairly hard work in still air was impossible. The wet-bulb temperature at which, with an air current such as might be expected along a well-ventilated working-face, and an amount of work such as an average miner does, the normal body temperature mould be maintained was not determined, and remains to be ascertained. Judging, however, from such observations as have yet been made in deep and hot mines, this wet-bulb temperature is not much above 80 deg., and for the purposes of the present Report we may provisionally assume it to be 80 deg.

In this country the outside wet-bulb shade temperature, in even the hottest summer weather, is seldom above 70 deg., and then only during the hottest part of hot summer days. A wet-bulb shade temperature over 73 deg. is scarcely ever experienced, and such a temperature is exceedingly trying to persons wearing ordinary clothing. In a mine, however, clothing is reduced or discarded as the wet-bulb temperature rises, so that men may be quite comfortable at wet-bulb temperatures of 80 deg. or more. In some tropical countries the shade wet-bulb temperature is often over 80 deg. for several days at a time; but in dry tropical heat the wet-bulb temperature is often below 70 deg., although the shade temperature is 110 deg. or more.

It seems evident from the foregoing considerations, that in dealing with the difficulties caused by heat in deep mines the chief aim of mining engineers must be to keep down, not the air temperature itself, but the wet-bulb temperature; and a subsidiary aim is to keep the air in motion as far as possible at all working places. We may now consider generally how these objects may be atained, leaving detailed discussions to further reports.

With increasing depth, the natural temperature of the strata increases steadily; and a common rate of increase appears to be about 1 deg. in 70 ft., though this is one of the questions on which we are collecting data. Thus, assuming that the mean surface temperature in this country is about 49 deg. Fah., the natural rock temperature at 2,200 ft. will be about 80 deg. If, therefore, there was very little ventilation, the air temperature would not be less than 80 deg., and the air would be saturated with the moisture given off from the damp strata. Actually, however, the air

would be saturated at over 80 deg., as oxidation of coal, timber, etc., would raise the temperature. There would, therefore, be very serious difficulty from the heat. If, however, the ventilation were adequate, the conditions would be very different.

Thus the problem of underground temperature control seems to resolve itself into that of adequate ventilation, planned with a clear conception of what is required in order to prevent loss of the miners' working capacity, and not merely to obviate trouble from firedamp or vitiation of the air by other gases. Our investigation is being carried out with this provisional conclusion in view, and we are collecting evidence for the purpose of testing it in every way, and of throwing light on all the factors which have to be taken into account in controlling the wet-bulb temperature underground.

It is our intention to present further and more detailed Reports, both on what has already been done and on future progress. The conclusions reached in the present Report may be summarised as follows :—

(1) The hindering effects on men of the heat in deep mines depend, not on the temperature of the air, but on the wet bulb temperature and the degree of stagnation of the air.

(2) In the downcast shaft and main intakes of a well ventilated coal mine the natural temperature of the strata has no appreciable influence either on the temperature of the air or on th[illegible] temperature.

(3) The data as yet available indicate that by properly-designed ventilation and avoidance of leakage the hindering effects on men of the heat in deep mines can be obviated up to any depths at present contemplated in the working of coal or other minerals in this country.—1st Report of Committee, *I. and C.T.R.*, Sept. 12, 1919, p. 328-9. (J. A. W.)

Summary of Draft Regulations for Rescue Apparatus under the Coal Mines Act. "The breathing apparatus provided at a rescue station or mine shall be of a type for the time being approved by the Secretary of State.

The reducing valve shall supply not less than two litres of oxygen per minute.

The oxygen in every cylinder shall be analysed before being used in a breathing apparatus, and shall not contain more than 2% of impurities.

Every breathing apparatus shall be thoroughly tested before being used, and at least once a month.

Flow meters shall be tested for accuracy at least once in every six months."—*Iron and Coal Trades Review*, March. 19, 1920, p. 390. (J. A. W.)

Abstract from a paper on Miners' Nystagmus. Dr Lister Llewelyn on means of prevention.—"A valuable paper on the cause, symptoms, incidence, and means of prevention of miners nystagmus was contributed by the author at the meeting of the North Staffordshire Institute of Mining Engineers held at the Mining School, Stoke, recently.

The author urged the dominating importance of increased illumination in safety-lamp mines, and suggested that the Mining Association of Great Britain and the Miners' Federation should each contribute £50,000 to a fund for research into better means of illumination.

In the course of his paper he stated that there had been two chief views as to the causation of the disease—(1) the position assumed by the miner at his work, and (2) deficient illumination. Most English observers now held that the chief factor was deficient illumination. There were two distinct varieties of the disease. In the first, the symptoms were absent or latent, and the man, suffering no diability, was unaware that he had nystagmus; in the second, the disease was manifest, and the man is more or less incapacitated. In his own series of 1,400 consecutive cases, 1,152 were manifest and 248 were latent.

Physical Signs.—The signs of the disease, continued the author, are as follows: Involuntary and irregular movements of the eyeballs, chiefly of a rotatory character, tremor of the eyelids, eyebrows, head, and, in some cases, even of the neck and shoulders. A backward inclination of the head, with drooping eyelids is characteristic and common.

Liability to Accident.—Is a man with nystagmus a danger to himself and to others? I believe many small accidents and probably some severe accidents, are the direct result of the disease. I have known of many men being sent out of the pit by the manager for fear of this danger. There is, however, the possibility of a greater danger, namely, that a catastrophe may result from the failure of a fireman or collier suffering from the disease to detect the presence of gas.

Colliers are said to be particularly predisposed and holing, because of the strain put on the eyes is a special factor in the causation of the disease.

Nystagmus is common in safety lamp mines, practically unknown in naked light mines. It is unknown in metalliferous mines. As the ordinary safety lamp is equal to less than one-third standard candle power, and when dirty gives as low as 1/10 s.c.p., the intensity of illumination, as compared with the ordinary candle is low, and to this the author ascribes the prevalence of nystagmus in safety lamp mines. He measured the actual amount of light falling on the working places in several collieries. In open light collieries the average was 0·09 of a foot candle, in safety-lamp collieries it was 0·018, or 1/5 of that obtained from an open light.

Prevention of Nystagmus.—Deficiency of illumination as the factor in the production of the disease is so important that all other factors sink into insignificance. Fortunately, it is a factor which can be dealt with. There are three main considerations which must be taken into account, namely:—(1) Nystagmus is a disease of gradual onset, and the average number of years of underground life before failure was 25 years. (2) The illumination in open-light pits is five times that in safety-light pits. (3) Cases of nystagmus, although uncommon, do occur in naked-light pits.

The conclusions drawn are—(1) That the full benefit of any measures taken will not be effective for some years. (2) That the illumination in safety-light pits must be increased at least five-fold. (3) That nystagmus will not be completely eradicated.

It may be objected that a lamp of 5 candle-power is not practicable. In the first place we should remember that neither was a submarine capable of carrying a 12 in. gun, nor an aeroplane capable of flying the Atlantic, nor an R33 possible before the war; but that, as a result of combined research and a determination to succeed, they are

now familiar facts. In the second place, a lamp of 5-candle power is not necessary. Despite the theory of relativity, the law of inverse squares still holds for illumination. If you place a lamp of 1-candle-power in the miners' cap, you will increase the illumination at least five times. A little consideration will make this clear; the lamp is nearer the coal-face and is not left hanging on a post many feet away; the candle-power is greater than that of most lamps in present-day use, and the rays fall more or less at right-angles to the surface and not *into the workers' eyes.* Rays of light falling on a surface at angle of 60° give only half the light of rays falling at right-angles. The absence of glare will be greatly appreciated by the men.

In a letter to *The Times* of March 7, 1919, Dr. J. S. Haldane wrote strongly of the comfort and efficiency of an electric lamp which had been tested by the scientific staff of the American Bureau of Mines."—L. LLEWELYN.—*Iron and Coal Trades Review*, Jan. 16, 1920, p. 71. (A. J. O.)

MISCELLANEOUS.

THE SHIMER CASE-HARDENING PROCESS.—The process consists of case hardening in a bath of fused salts, to which about 5 per cent. calcium cyanamide in lump form is added. For the bath good results are obtained from equal proportions of sodium chloride, calcium chloride and baium chloride—or for a very liquid bath potassium chloride may replace sodium chloride. The cyanamide used should be in lump form, and should not have been exposed to the air.—J. W. RICHARDS, *Iron and Coal Trades' Review*, Aug. 15, 1919, p. 200. (J. A. W.)

MINERS' INSURANCE—AN INDUCEMENT TO LONG SERVICE.—Four mining companies at Tonopah have adopted a plan of 'blanket' life insurance for all employees of both mines and mills, distinct from, and in addition to, any compensation provided by the State law. The amount of insurance is based on the length of time, beyond a minimum of two months, the individual has been continuously employed. Beginning with $500, the amount increases in several steps so that after one year the beneficiary, in case of the employee's death, will receive $1250; and after two years, $1500. This method recognises, and will tend to decrease, the practice of changing continually from one mine to another or from one district to another."—T. A. RICKARD, Editor.—*Mining and Scientific Press*, March 13, 1920, p. 363. (C. J. G.)

Abstract of Patent Applications.

719.19 Dickson & Beaton. Improvements in supplying water to hollow rock drills. 6.9.19.

This application is for a type of detachable shank for use with air feed, hand rotation type drills, and is intended to give a positive supply of water to the drill bit, and at the same time prevent water reaching the working parts of the drill.

The application consists of a chamber with hose connection, into which the drill and a detachable shank are fixed at opposite ends by means of taper sockets.

824.19 Det Norske Aktieslaskab for Elektrokemisk Industri Norsk Industri Hypotebank of Toldbodgaten. Improvements in or relating to electrodes for electric furnaces and the like. 10 10 19.

This application refers to improvements in or relating to electrodes for electric furnaces and the like, and specially refers to the making of electrodes inside a metallic mantle or casing which holds the mass together during baking, protects it from oxidation and increases the electrical conductivity and the mechanical strength of the electrode.

54.20. Laminated Coal, Limited. Apparatus for the manufacture of a solid fuel. 17.1.20

This specification describes an apparatus for the production of a solid fuel having the same characteristics as laminated coal. The fuel is made from waste coal, coke, or wood-dust mixed with tar and pitch suitably heated in a chamber in the ordinary manner of making briquettes, and is then extruded through a rectangular box containing parallel plates whereby the fuel is divided into layers, which are then partially cooled to the point that when the layers are subsequently pressed together they do not perfectly adhere but sufficiently to stand handling and transport. The specification provides for cool air being forced through the layers during process of manufacture if found necessary or the layers being sprayed with dust to prevent adhesion during the subsequent pressing; the object being to provide a good quality laminated fuel, the layers of which will gradually separate under the influence of heat or which may be cleaved by a blow like laminated coal.

256.20 American Coke & Chemical Co. Coke ovens and cooking processes. 19.3.20.

This specification relates to an improved method of heating coke-ovens.

276.20 H. Tindale. Improvements in the distillation of coal tar and the products derived therefrom. 23.3.20.

The applicant describes and claims both a method and apparatus for distilling.

302.20 Barratt, Pillans & Du Toit. Improvements in hose and pipe couplings. 3.4.20.

This application refers to couplings for fluid connections of the kind comprising a " spud " on to which is screwed a union nut, the latter having an internal flange which engages behind a collar on the tail piece. And more particularly to such connections for conveying air and water to rock drilling machines.

It is proposed to use only one size of spud and union nut for varying sizes of hose for example, ½-inch, ¾-inch and 1 inch, the tail piece being adapted to enter the size hose with which they are to be used, but standard so far as the flange or collar is concerned which engages with the union nut. By this means one size spud and union nut is capable of connecting different sizes of hose.

303.20 Barratt, Pillans & Du Toit. Improvements in hose connections 27.3.20.

This application refers to hose connections and more particularly to those used on axial water feed rock drilling machines for conveying water to the axial tube.

These frequently consist of a "spud" which screws into an aperture in the back cover of the drill to which the hose conveying water is connected by a tail piece and union nut in the usual way.

It is proposed to make the union nut, the collar on the tail piece, and the threaded end of the spud which received the union nut, standard and consequently interchangeable with the ordinary hose connections used in the mine for other purposes.

315.20. N. McKechnie Barron. Improvements in or relating to sand filters. 6.4.20.

This application relates to a type of water filter which consists of a number of sand chambers and means for passing water through the sand contained, together with means for cleaning out the dirty sand and admitting a fresh charge at intervals.

316.20. American Coke & Chemical Company. Improvements in the art of heating walls or the like for coke-ovens and the like structures. 7.4.20.

This application is intended to secure uniform heating of coke-ovens by introducing jets of gas at various points along the walls of the oven.

323.20. Worthington Pump & Machinery Corporation. Improvements in filter press. 8.4.20.

This application relates to an improved pressing machine, in which the press, body and pressing members, consisting of a pair of fluid controlled cylinders and pistons, are mounted on levers which open and close the body of the press. This body comprises the two end plates and a series of grid plates to be placed between the bags containing the material to be pressed.

327.20. The Nitrogen Corporation. An improved process of synthesising ammonia from its elements. 8.4.20.

This application relates to a process for fixing free nitrogen in the form of ammonia by the use of a complex catalyst.

329.20. Scovill Manufacturing Company. Electric furnaces. 8.4.20.

This application refers to electrical furnaces for melting metals of high thermal conductivity, and is arranged so as to obtain and control the temperature of the furnaces within the desired limits.

333 and 335.20. Calverley & Highfield. Improvements in and relating to apparatus for transforming electrical energy. 8.4.20

These applications refer generally to a transforming apparatus provided with an exciting winding upon the alternate current transforming structure, specially connected to obtain the conversion required.

331.20. Ennis & Dorman Long & Co., Ltd. Improvements in or relating to steel-framed cottages. 8.4.20.

This application refers to the construction of cottages comprising a series of steel frames and concrete slabs.

421.20 John Morris. Improvements in safety appliances for colliery cages and the like. 29.4.20.

This specification describes a safety appliance for supporting colliery cages on the breakage of the winding rope. An additional rope, which may be a discarded but serviceable winding rope is suspended from an auxiliary sheave in the headgear and is fastened to the bridle-chains of each cage—the sheave is provided with a brake-drum to which a brake is automatically applied to arrest the cages or release of a weighted lever controlled from the engine room.

Changes of Address

Blandford, T., *l/o* Johannesburg; 15, South Parade, Doncaster, England.

Brink, C. G., *l/o* Sheba; Central Works, Transvaal G.M. Estates, Ltd., Pilgrims Rest.

Fiander, R., *l/o* Cleveland; 63, Queen Street, Kensington East, Johannesburg.

Harley, J. P., *l/o* Tavoy, Lower Burma; c/o H V. Low & Co., Ltd., P.O. Box 383, Rangoon, India.

Macdonald, F. G. *l/o* Witpoortje; New Transvaal Chemical Co., Delmore.

Olsson, C. H., *l/o* Johannesburg; African Paints & Oils, Ltd., P.O. Box 1365, Durban.

Pirow, H., *l/o* S.A. School of Mines, Johannesburg; 153, Buiten Street, Sunnyside, Pretoria.

Tutt, C. J., *l/o* Johannesburg; Southern Van Ryn Reef G.M. Co., Ltd., P.O. Box 41, Nigel.

Associated Scientific and Technical Societies of South Africa.

JOINT HOUSING.

The total amount of subscriptions to the Joint Housing Fund of the C.M. and M.S. received to 31st August is as follows:

41 Members and Associates . £166 16 0

while the sum of £50 has been received from an outside source and the Society has donated £150 from its own funds, making in all, £366 16s.

It is hoped that members and associates who have not yet subscribed will respond as early as possible on the appeal form appearing in the advertisement columns of this issue.

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THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA.

Vol. XXI. SEPTEMBER, 1920. No. 3.

Proceedings AT Ordinary General Meeting, 18th September, 1920.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology, Johannesburg, on Saturday, 18th September, 1920, Mr. J. Chilton (President) in the chair. There were also present:—

17 Members: J. R. Thurlow, H. R. Adam, C. J. Gray, J. Hayward Johnson, J. J. R. Smythe, John Watson, E. M. Weston, H. A. White, J. A. Woodburn, Jas. Gray, J. A. Wilkinson (Members of Council), H. E. Barrett, W. Beaver, T. Proberts, J. T. Triggs, H. R. S. Wilkes, and L. B. Wilmot.

3 Associates: S. Evans, R. W. Irwin, and H. L. Krause.

2 Visitors, and H. A. G. Jeffreys (Secretary).

MINUTES.

The Minutes of the Twenty-fourth Annual General Meeting, held on the 26th June, 1920, as recorded in the June *Journal*, were confirmed.

NEW MEMBERS.

Messrs. J. Watson and Jas. Gray having been elected as scrutineers in connection with the ballot for the election of new members, the following were declared unanimously elected:—

EATON, JOHN KYER, 35, General Mining Buildings, Johannesburg. Engineer.

FLETCHER, WILLIAM HORTON, P.O. Box 508, Bulawayo. Mining Engineer. (Transfer from Associate Roll.)

NESS, THOMAS RAMSAY, Modder "B" G.M. Co., Ltd., P.O. Modderbee. Mine Shift Boss.

ORTLEPP, JULIUS ADOLPH, University College, P.O Box 1176, Johannesburg. Metallurgist.

PROBERTS, THOMAS, Village Main Reef G.M. Co., Ltd., P.O. Box 1091, Johanesburg. Mine Overseer.

RAMSAY, RALPH, Princess Estate & G.M. Co., Ltd., P.O. Box 112, Roodepoort. Surveyor.

WILSON, WILLIAM PEARSON, Village Main Reef G.M. Co., Ltd., P.O. Box 1091, Johannesburg. Mine Overseer.

The Secretary: The following gentlemen have been admitted by the Council as Associates:—

CHARLES O'CONNOR FERRERO.
RODERICK HENRY HEANEY.
IAN SCOTT HENDERSON.
AND ALBERT EDWARD IRWIN.

GENERAL BUSINESS.

RESEARCH ENDOWMENT FUND.

ALTERATION TO CONSTITUTION AND RULES.

The President: In terms of the amendment of the Constitution and Rules carried at the Special General Meeting on 26th June last, the addition to Clause 34, sub-section (a), has been altered by the substitution of the words "any year" for "the year."

Sub-section (a) originally read as follows:

> "Providing medals or other prizes as the Council may direct for the best paper or papers read before the Society during the year."

It was pointed out that the sub-section, as worded, would involve the expenditure of all the revenue in the year in which it was received. Your Hon. Legal Advisers have been consulted, and advise that the sub-section be altered as stated, so that it will now read:—

> "Providing medals or other prizes as the Council may direct for the best paper or papers read before the Society during any year."

ASSOCIATED SCIENTIFIC AND TECHNICAL SOCIETIES OF S.A.

The President: I should like to refer to the Associated Scientific and Technical Societies of South Africa. You will be aware that subscriptions for that fund are

coming in slowly. Our Society, from 44 Members and Associates, has subscribed the sum of £166 16s., while the sum of £50 has been received from an outside source, and the Society has donated £150 from its own funds, making in all £366 16s. It is hoped that Members and Associates who have not yet subscribed will respond as early as possible to the appeal appearing on page 36 of our *Journal*. It seems rather a pity now that we have advanced so far upon the way that these subscriptions are coming in so slowly. When we remember the excellent work which was put in at the beginning by Prof. Wilkinson, who toiled early and late to get this scheme forward—serving on the Joint Committee for over five years—the present state of the Fund is rather disappointing, because the work that was put in by Prof. Wilkinson and Mr. Meyer during that long period certainly helped to put the fund on such a footing that we expected better things than have been accomplished. I feel sure this fact only needs to be mentioned and subscriptions will come in.

Mr. H. A. White *(Member of Council):* I should like to remark that the Council of the Associated Technical Societies have allocated as our share at least a thousand pounds, of which we have got one-third at present. It therefore behoves every member, not only himself to subscribe, but to induce other members of the Society to subscribe to the full extent of their means for an object which, I think, all will admit is exceedingly worthy.

WELFARE WORK ON THE WITWATERSRAND.

PRESIDENTIAL ADDRESS.

By J. Chilton.

Not many years ago the establishment of conciliation boards and wage councils was regarded as practically the solution of the labour question. It was fondly imagined that the full and free discussion of any industrial problem would inevitably lead to some solution satisfactory to both parties in a controversy. Unfortunately, the lofty hopes built on this foundation have not been realised in practice, and the antipathy between Capital and Labour to-day is as pronounced as ever.

Probably the explanation for this failure is to be found in the strictly defensive origin and outlook of the parties that compose these boards. They only meet together when one has a demand to make of the other, or when a conflict is threatening; consequently they always meet in an atmosphere of antagonism, and the council chamber becomes the fighting ground of bodies animated with the lust of battle.

Negotiations often only take place when a stand has been taken by both parties, and prejudice or prestige becomes an obstacle to reasonable concessions. It seems desirable that employers and employees should meet on some common ground outside the arena of labour questions, where the hostile element is excluded, so that the understanding and goodwill created there might be utilised in times of industrial overstrain and unrest.

In the writer's opinion, this common ground may be found in the "Welfare" movement which in recent years has become such a marked feature of the industrial life of Great Britain. It is not suggested that this movement will be a cure for all the ills of the industrial world, but it is maintained that through the "Welfare" policy such a fostering of the spirit of goodwill, co-operation and team work may be brought about as will change the tone and temper of our industrial controversies.

The root idea of the "Welfare" movement is that employers of labour have a serious responsibility when dealing with their staffs. They cannot evade that responsibility simply by the payment of wages, however high. Every employer has a moral obligation to see that his workmen are living and working under reasonable conditions that will allow them not only to do their duty to their wives and families, but also to undertake the rights and duties of citizenship.

Some who complain of Trades' Union action seldom think of voluntarily improving the condition of their workmen. If employers were more ready to improve the

industrial conditions when circumstances permitted, their action would be appreciated and a better spirit might be shown in our industrial council chambers.

The basic idea of the "Welfare" movement is by no means new, but when the British Health of Munitions Workers' Committee took it up during the war period, they put a new emphasis on an old idea and achieved results that can only be regarded as astounding. This Committee was created because the results being obtained in the munition works of Great Britain were so disappointing as to imperil the national existence.

On the battlefields of France the daily expenditure of explosives was greater than the production of the factories, and on more than one occasion the Allies' armies had to retreat because the supply of high explosives was inadequate.

To remedy this, munition works were established all over the United Kingdom, elaborate machinery was erected and the world ransacked for men to direct operations, but in spite of these measures the supply of munitions remained still insufficient to meet the daily demand and allow a reserve for special occasions.

In looking for the cause of this failure, attention was first given to factory buildings, but these were found to be laid out so as to secure the best results and no radical improvement could be suggested.

The machinery was next examined, but as the most up-to-date mechanisms had been erected, little hope was entertained of better mechanical devices.

The Committee then began to study the personnel of the service, and it was discovered that much of the delay and disappointment could be traced to the physical and mental conditions of the munition workers. In many cases it was found that the hours of labour were excessive, and that the workers were often completely tired out before the end of the working day.

This discovery suggested a reduction in the hours of labour, and when this was accomplished it was found that the output per worker increased considerably. Further investigations into the question of industrial fatigue, motion study, and rest periods were carried out and certain conclusions arrived at.

The knowledge so gained was applied in all the factories under the Ministry of Munitions, with such results as astonished the investigators. Finally, a close personal study of every munition worker individually was made; his home, social surroundings, and his leisure. His education, health, outlook and mental equipoise also received attention.

Whatever conduced to the welfare of the worker was fostered and extended, and the interest shown by the employers was very soon reflected in the returns from the factories; better work was done, better time was kept, and, above all, a better spirit was shown. From the improved conditions a spirit of goodwill, co-operation, and loyalty sprang up. In many cases outputs were doubled and expenses proportionately reduced.

The period became the golden age of both master and man, and when the Armistice was signed, in spite of the general relief at the conclusion of war, much regret was expressed at the passing of labour's millenium.

Such was the beginning of that policy, which afterwards was named the "Welfare Movement." But the seed sown in the midst of war has not been allowed to wither away, and to-day this movement is rapidly spreading through the industrial world.

Many firms have instituted a "Welfare" department under the charge of a responsible official, whose chief duty is the application of tests by which workers can be appointed to occupations for which they are physically and mentally fitted, and to study and determine the conditions which tend to the mental and bodily health of the workers and which promote harmony and co-operation between master and man.

Some employers of labour regard this movement as a fad, a coddling and paternal sentiment closely allied to weak benevolence and philanthropy. Many workers, on the other hand, regard it as an attack upon the sacredness of private life and as an imperfect substitute for a square deal. But these misunderstandings are rapidly being cleared away, and both worker and employer are beginning to realise that a place for human personality can be found even in mines and workshops. After all, "Welfare" work is really the creation of those conditions that will enable the individual to do his best, and its chief feature is the utilisation of that fund of goodwill and loyalty that exists in every working community.

The aim of this address is not to plead for the introduction of the "Welfare"

movement into the mining industry, for that took place many years ago, but to ask that a new emphasis should be placed on this feature of our activities.

At one time the social conditions on our mines were well in advance of the rest of the industrial world, but since the war we have lost this pride of place, not because the work has slackened off, but because other industries have pushed ahead, the pace no doubt being accelerated by close proximity to the battlefields of Europe. In spite of this advance, the Rand miner can still give a smile of amusement at the fierce controversy now raging in England over the question of pithead baths, for these have been a commonplace in the Transvaal for over thirty years.

In the matter of housing accommodation our mining community is not surpassed in any other field of industrial activity, and on this alone no less a sum than £1,650,000 has been invested. On sports grounds and recreation halls £120,000 has been spent, and hospital accommodation has cost over £250,000; so the industry cannot be accused of indifference to the welfare of its employees.

Then we have the sports movement, the First Aid and Safety campaign, the Whitley policy, and the co-operative project. These and the general improvement in underground conditions all point to the fact that the tragedy of toil is receiving close attention.

The physical condition of the worker is being also studied, and the Medical Research Bureau has already achieved results that have startled the medical world. Miners' phthisis, tuberculosis and pneumonia are being scrutinised, and sanitoria for the treatment of these diseases have been established, and obscure and tropical diseases are also being investigated.

Whatever tends to increase the welfare of the industrial worker seems to be an object of thought and research

Because the industry has done so much it can be expected to do still more and further advances in the Welfare movement may be confidently anticipated.

Probably the Mines Department may justly claim some of the credit for the improvement in underground conditions during the last decade, but without the active co-operation of the captains of industry, much of that improvement would have been impossible.

Ventilation, sanitation, and dust-allaying is receiving increased attention, and the lowered accident rate is a record which any mining community might envy. Industrial diseases, such as lead and mercurial poisoning and cyanide rash, are being investigated and eliminated.

As for the future, there is little fear that the movement will spend itself, and the writer anticipates further advances in the direction of vocational training, industrial surgerys, mining banks, Welfare supervision, circulation of technical literature, improved medical service, time studies, fatigue tests, lighting of workshops, old age persions, and scientific management.

Like other movements in the direction of social progress, Welfare work will never be able to show up in imposing figures upon balance sheets, but it must be remembered that this policy increases goodwill, and goodwill increases output.

The manifestation of the spirit of co-operation which has been such a welcome feature in mining life during the last few months is an indication that a more human touch is being manifested in our industrial quarrels, and a realisation that what the worker seeks in industry is "not a living but a life."

Mr. J. R. Thurlow *(Hon. Treasurer)*: I have very much pleasure in moving a hearty vote of thanks to our President for his most instructive address.

It has been my privilege for the last two years to hear the addresses of our Presidents. and, good and able as they have been, I must say that our President to-night is to be congratulated on having struck a new note. The principal features of the previous addresses to which I refer have been essentially destructive, and it is a great pleasure to listen to something on the constructive side.

I entirely agree with the remark that, as a rule, discussions between employees and employers have hitherto been in an atmosphere of antagonism—I have been present at some of them. I feel sure that the majority will agree with the suggestion that some more common ground, from which the air of antagonism would be absent, would improve the amenities and make for a better understanding of each other's views, which should be beneficial to both parties.

Mr. Jas. Gray *(Past-President)*: I have much pleasure in seconding the vote of thanks to Mr. Chilton for his able and interesting address. The address is certainly constructive, and I hope that the future will see some of the suggestions made carried out.

THE IDEAL MINING LAW.

By Mr. C. J. Gray *(Member of Council)*.

My subject is "The Ideal Mining Law." For illustration, where such is considered desirable, I have used the Natal Mining Law (Act 43 of 1899), not because it is the ideal, but because I am, or was, specially familiar with it, having both administered it and served on the Committee which drafted the Bill upon which it was based.

An ideal mining law is unobtainable, as there are too many conflicting interests and practical difficulties to be overcome, and as some of the desiderata are incompatible. Its consideration, however, is not futile, as the practical law, either during construction or administration, may best be judged by ascertaining how closely its provisions approximate to, or how far they depart from the ideal.

The object of a mining law should be to provide satisfactorily for: I. Transition from prior laws; II. Removal of obstacles to mining; III. Removal of discouragements to mining; IV Encouragement of mining; V. Control of mining; VI. Revenue collection; and VII. Administration.

It will be most convenient if my views as to the ideal law are given under these headings:—

I.—Transition from Prior Laws.

(*a*) The legitimate interests of persons holding titles under prior laws should be fully protected. Both justice and the reputation of the country as a safe field for mining investment require this, but conversion of title should be encouraged, so that there may be uniformity and simplicity in administration.

(*b*) The alterations from prior laws should be few, and such that they may be readily grasped by those concerned. Comparatively few men ever become thoroughly familiar with the provisions of a mining law, and it is undesirable that the troubles which arise from mistakes by prospectors and others, even under an old law, should be added to by new and complicated provisions.

There is often reason to vary fees and labour conditions according to length of time after registration, situation of the claim, nature of mineral, work done in the past or to other circumstances: such variations will, however, cause difficulties, especially in cases where one man or syndicate holds claims registered on different dates, or otherwise liable to different fees or conditions.

II.—Removal of Obstacles to Mining.

(*a*) The whole mineral resources of the country should be rendered available for exploitation by persons having the necessary will and means. No person should be permitted to prohibit mineral development either directly or by demand of prohibitive terms.

Obviously that is the ideal from the mining point of view, but, equally obviously, conflicting interests make that ideal impracticable of attainment.

In Natal, speaking generally, the owner of private lands has no right to prevent prospecting or mining, on uncultivated lands, for minerals other than coal, limestone, stratified ironstone, slate, and soapstone. When the Mines Act came into force he was given twelve months' exclusive right to take out, or permit others to take out, prospecting claim licenses. That period having elapsed, anyone depositing £2 10s. per license as security for repair of surface damage, may apply for not more than four licenses for the owner's land. The owner may object to issue of these licenses, the decision resting with the Deputy Commissioner of Mines, subject to appeal to the Minister. If the licenses are issued, claims may be pegged under the licenses, not more than two claims being pegged in one line. The claims are 18½ acres each in area for gold and other minerals except precious stones and alluvial minerals, or 0·23 acres each for precious stones, alluvial minerals and all other minerals. Registration of the claims must be granted, but if the landowner objects, the grant is subject to such conditions, including payment of compensation, as the Minister thinks proper. For three months after the owner receives notice of the first issue of licenses, he has an exclusive right to take out licenses, but subsequently issue of licenses to others as well as the owner may be resumed

The owner pays only half license fees and royalties for his licensed holdings, and he receives half of the moneys collected as license fees, royalties, or penalties other than those for contravention of the Mines Act or Regulations, in respect of other licensed holdings on his land.

Under those provisions the would-be prospector or miner gains much by coming to terms with the owner, but the possibility that the prospector may get four claims despite the owner, makes the latter a more reasonable person to deal with. The provisions prevent owners from retarding the progress of the country by absolute exclusion of prospecting for minerals on private lands.

(b) No person under pretence of mineral development should be permitted to hold, to the exclusion of others willing to work, an area of ground out of proportion to the amount of work he does.

The question of labour conditions is one of the most difficult in mining law. In dealing with it, one should remember that it is not simply holding ground insufficiently worked, but preventing other persons from working, which is objectionable. On the one hand, stringent labour conditions repel the capitalist, who resents interference with his liberty to adjust his expenditure in accordance with his own views, and with money market conditions. On the other hand, lax conditions allow ground to be held, for purely speculative purposes, by men without the means or intention to work it, and they too often, owing to greed which may be founded on genuine optimism, hold it to the exclusion of those who would work the ground. The practical difficulty of striking a mean is immensely increased by the variations in the nature of mineral deposits and in the circumstances under which they occur. On one piece of ground an outcrop of a workable reef may be known, an adjoining piece may be believed to be underlain at a depth of some hundreds of feet by the extension of that reef, while on still another it may be thought worth while to search for an unknown reef because geological conditions are similar to those on the first piece. Obviously, the appropriate labour conditions for holdings on the three pieces of ground are not the same. In the first case there should be definite development work, *i.e.*, shaft sinking and level driving; in the second, work could fairly be postponed until proof of the outcrop mine justified heavy expenditure for prospecting by deep shafts or otherwise; while in the third, surface examination with panning of gravel and soil might be sufficient and appropriate.

The old Natal and Zululand laws of 1888 and 1894 made definite work compulsory, with the result that much money was wasted in shafts, etc., which had no justification in outcrop observations. The money lost in such useless work has helped to produce widespread belief that no mineral deposits of value except coal are to be found in that country. The present Natal Act, prepared with keen realisation of the drawbacks of the older laws, allows commutation of the labour conditions for a money payment. It has swung too far from the old position, for experience has shown that it has not guarded sufficiently against ground being held unworked.

It appears that the question whether there should be a labour condition or not, and if there is, what form it should take, should be answered differently for different localities.

(*c*) Purely speculative pegging and holding ground until compulsorily declared abandoned months afterwards should be prevented.

When interest is directed towards a particular district, say in case of a discovery, numbers of persons take up claims. Many do not intend to spend money on the claims or to enhance the value of the ground by work, but hope that they will have sold them before the claims are declared forfeited by the Government for non-payment of license fees or for non-working. The objections to that practice are obvious. Interest is killed, as would-be workers who visit the district return disgusted when they find all the ground pegged, and that they cannot get it without paying toll to men who have spent nothing on the ground. The effect of the abuse extends, as though the genuine worker generally does not buy, the syndicate promotor sometimes does so. Neither the price nor the actual value of the ground matters much to him, for even if he pays cash he counts on recovering his expenditure and much more from the ignorant at a distance. A large proportion of the money paid by the shareholders of a syndicate thus formed is not expended in work on the ground.

The Natal Act lends itself to the abuse, as under it a man may peg and hold ground locked up, at a cost of 9s. per claim, for thirteen months.

(*d*) Persons engaged in mining should be able to acquire readily those facilities, such as water rights, machine stands, residential sites and rights of way, which they require.

It may be of interest if I mention that the Natal Act empowers the Minister, when he considers it in the public interest to do so, to authorise, in connection with mining, the construction of roads, railways, water-races, dams, shafts and drives, or the taking of water, or exercise of any other rights of the nature of servitudes upon or over any lands. Compensation to the owner of the land for loss sustained by him is determined under the Natal Land Clauses Consolidation Law, and is payable by the person applying for the right or servitude.

III.—Removal of discouragements to Mining.

(*a*) The law should be easily understood, so that mistakes may be avoided. It should be brief and its construction and expression clear, and particularly clear in those portions which concern the prospector, who often has had little literary education. It should be practical, and demand no impossibilities, such as pegging with reference to the strike of an unknown reef.

(*b*) The method of marking holdings should be such that prospectors can readily ascertain on the ground what areas are held, and what are open to prospecting and pegging. The prospector should not lose time and money through uncertainty and error.

Not only should claims be marked by a sufficient number of good pegs or beacons, easily seen above the grass, but those pegs should be removed promptly on abandonment or forfeiture of the claims. There is, however, practical difficulty in securing removal of pegs, more especially when the registered claimholders are not the real holders.

(*c*) Proper provision should be made for registration of rights, and the records should be readily accessible to the public.

(*d*) Acquisition of title, especially prospecting title, should be very simple. All formalities, delays and incidental expenses should be cut down as much as possible, but in practice the need for security of title often requires expense and delay over notices, surveys and enquiries.

(*e*) The number of fees payable should be small. An excessive number of small fees gives the prospector or miner the idea that he is being "fleeced" at every turn. Payment of such fees also involves considerable inconvenience to prospectors in out of the way places, and to small and loosely organised syndicates and partnerships.

(*f*) Title to holdings should be secure. The person spending money on a holding should be certain that he will not lose the holding through inadvertence, default of an employee or adverse exercise of discretionary power by an official. In drafting a bill there is temptation to make forfeiture the penalty for various offences such as irregularities in pegging, delays in payment of fees, non-observance of labour conditions, or false declarations of discoveries or work done, but these may be due to neglect or misconduct of a servant of the claimholder or to misjudgment or mistake of the claimholder himself. It may be provided that officials shall exercise discretion in such cases, but the capitalist is not inclined to invest on the security of official discretion.

(*g*) The relative rights of landowners and mineowners should be so adjusted and defined that friction will be avoided.

It should be provided that at some stage of mining full surface rights shall be given to the mineowner in return for compensation or under other arrangements. As mining progresses the surface interests of the landowner are interfered with more and more, ground being built over, cut up or covered with dumps, while on the other hand, the restrictions adapted to the prospecting stage, placed on the mineowner for the protection of the landowner, become very irritating.

IV.—Encouragement of Mining.

(*a*) The finders of valuable minerals should be encouraged to disclose their discoveries. Attempts to compel declarations of discovery are futile, as if a man keeps his discovery secret he cannot be punished, and the threat of punishment will tend to make him more secretive Something can, however, be done by giving encouragement to disclosure, either by allowing the discoverer to obtain title to his discovery readily, and on terms which commend themselves to him, or by offering rewards for discoveries.

(*b*) Direct encouragement should be given to mining by various forms of aid unless adequate aid is given otherwise through Supply or other Acts.

(*c*) The law should be such that both prospectors and investors of capital are attracted. If successful mining is not estab-

lished, no mining law will attract many men, and if successful mining is established even a harsh law will not keep money and men away altogether. No mining law will serve as a substitute for valuable mineral deposits, but given those, or hope of those, a lenient and attractive law is highly desirable.

V.—Control of Mining.

(*a*) The law should be so drafted that its intentions cannot be evaded. Offences against it must be readily discovered and proved. It is useless to draft a law based on intentions without regard to the practicability of enforcement.

The practice of pegging " base metal " claims on gold reef in the Transvaal is widespread, and there is no effective check on it. In Natal a similar difficulty is guarded against. There the Commissioner of Mines may permit, in certain cases, the pegging and registration under restricted conditions, of " metal " claims over the larger and therefore cheaper " mineral claims," when minerals for which " metal " claims are necessary exist, or are likely to exist, on ground pegged as " mineral " claims.

(*b*) Punishment should fall upon the person really guilty of an offence. No person should be penalised unless he has done wrong knowingly or through culpable negligence; punishment should be adapted to the offence, and be secured at low cost in time and money to the Administration, and without exposing the offender to undue indignity

It is difficult to attain anything like that ideal in practice. Under the Natal Act the registered claimholder is the only person who can be punished for various irregularities, though his predecessors in title, employees, or persons with whom he is associated in a syndicate or partnership may be the real offenders. While that position sometimes involves punishment of the innocent, it more commonly allows escape of the guilty. The registered claimholder is often a " dummy " who cannot be found, or who is not worth suing, and the real holder cannot be touched. Punishment of faults by forfeiture of claims costs little, and avoids the indignity to the offender of a prosecution, and is sometimes, in one sense, adapted to the offence. The difference between forfeiture and non-forfeiture is, however, often great and an offence meriting punishment may not merit forfeiture. Again, if the ground is almost valueless, forfeiture is no penalty, while if it is valuable it may be a very heavy penalty.

VI.—Revenue Collection.

A reasonable amount of revenue should be provided for, unless other forms of taxation or the indirect benefits from mining are sufficient. The sources of revenue should be so selected that the revenue is collected without restricting genuine prospecting, development or mining. The forms and methods of collection should be such that mistakes or misappropriation by officials cannot escape detection.

The genuine prospector, and the man developing ground, and as yet getting no return for his expenditure should be taxed very lightly, if not indeed aided by the State, which may benefit considerably from his work. He certainly should not be called upon to pay more than his reasonable share in the expenses incurred in administering the laws with regard to prospecting and development and in providing facilities and conveniences for prospecting, development, etc. Revenue should be derived from established mines and not from prospecting works.

VII.—Administration.

(*a*) The arrangement of officials and their duties should be such that public business is transacted with the greatest possible accuracy, fairness and rapidity.

There should be either almost complete centralisation or almost complete decentralisation in administration. Centralisation has advantages—it enables the abilities of the various officials to be used to best advantage; it allows of a fair distribution of work; it avoids the delays in business involved in correspondence between offices, and it removes any uncertainty members of the public may have as to which official should be addressed on a particular subject. On the other hand, decentralisation has the advantages that it puts the official into closer touch with the men with whom he deals; it saves travelling expenses; it makes it easier for men to obtain information and to transact business by word of mouth, and it sometimes saves delay in communication by letters.

(*b*) The duties of the various officials should be clearly defined and properly adjusted. Each official should have his own sufficient sphere of duty and responsibility.

If he has that, he will probably have a sense of responsibility and take interest in his work.

(*c*) The discretionary powers of officials should be very limited. Where granted they should almost invariably be powers to lessen the onus of a provision and not to increase it. They should in no case lessen security of title.

In practice some discretionary powers must be given, as no mining law can be so framed as to meet all the variations of conditions which arise.

(*d*) The cost of administration should be low. What are at first sight small items in a law, may greatly increase the cost of administration by requiring the action of officials with special experience, or by involving considerable travelling or office work.

The matters dealt with above are those which may be considered essential to a complete mining law, but others are sometimes included, and sometimes dealt with in separate laws. They are:—

VIII.—Protection of Employees.

(*a*) By rules for safe working of mines.

(*b*) By providing for compensation in cases of injury or impaired health.

(*c*) By rules for the sanitation of mines.

(*d*) By special provision to secure the workmen's interests in cases of non-payment of wages.

IX.—Protection of Mineowners.

By provisions controlling such matters as trade in native gold and precious stones.

X.—Protection of the Public.

(*a*) By requiring fencing or filling of excavations.

(*b*) By providing for collection and publication of statistics.

(*c*) By imposing special checks on attempted mining swindles by such means as control of prospectuses and of capitalisation.

The President: I am sure we are deeply grateful to Mr. Gray for his really interesting paper. During the week that has just passed I have had occasion to go into the Transvaal Gold Law—and I can assure you that that is not the ideal Mining Law. The perplexities and the complexities of the different clauses are certainly a source of great income to the legal profession, but if we had a law something after the plan suggested by Mr. Gray, then the mine manager would have probably a better life and the lawyer a worse one. I have much pleasure in proposing a vote of thanks to Mr. Gray for his excellent paper.

Mr. H. A. White *(Member of Council):* I have very much pleasure in seconding the vote of thanks to Mr. Gray for his very excellent paper and for the simplicity of the law which he has produced for our approval. I like it particularly because he does not seem to derive it from the point of view of an official ridden community like Germany would be, for instance. He seems to have considered a little less officiality and a little more humanity would make a better law.

He makes no reference to the Apex Law of Mining in America, which I rather expected him to touch upon; but he certainly does make the point that every prospector should be able to mark on the surface exactly the amount of ground he is claiming —which, of course, puts the Apex Law out of court. He makes no reference to the multitude of irritating regulations with which our mining law is hedged around. That is, of course, a side issue. But I think it would be well to lay stress on the fact that though the health and safety of miners, of course, requires a certain amount of regulation, the fewer the regulations the more likely are they to be carried out.

NOTES ON ROUTINE ASSAYING AT THE GLOBE & PHOENIX MINE, SOUTHERN RHODESIA.

By Mr. H. R. Edmands *(Associate).*

(Printed in Journal, April, 1920.)

REPLY TO DISCUSSION.

Mr. F. W. Watson remarked that my paper was mostly confined to the physical side of assaying; this I quite realise, also that many of the departures from ordinary practice described could not be accepted without, at least, further explanation. In replying to the discussion, I therefore am glad to avail myself of his invitation to somewhat amplify the paper on many points.

Law of Averages.—From the fact that Poisson's law is used in statistical work, and from Beringer's investigations, I presume its correctness is not questioned, the point being how far it is applicable to the sampling and assaying of gold ore.

In Beringer's lecture on the theory of sampling, to which reference was made, the law was applied to ores containing copper, silver, etc., in a mineralised form, and its limitations were also indicated. I attempted to show how the same law would affect ore carrying value in metallic form. I did not claim that it could be applied to predict the errors possible in an assay, it obviously cannot, as the necessary data as to the number and weight of gold and quartz particles in the sample are lacking, but it probably governs the discrepancies occurring in assays that have been properly performed.

If this assumption is correct, it confirms the fact well known to all assayers that the chance of error is greatly increased by the presence of coarse gold, and that it is desirable to use that method of crushing that most effectually comminutes the gold. It was to emphasise these points that attention was called to the law. The examples given were purely hypothetical, and referred exclusively to samples composed entirely of equal-sized spheres, a condition of course never approached in practice, as was explained in a later paragraph.

They were deduced from the calculations given in Table I, which, apart altogether from Poisson's law, show incontrovertibly that in a 2 a.t. sample the presence of each single sphere of gold affects the assay to the extent of 1·65 dwt. per ton if of 1/100 in. diameter, and 7·02 dwt. if of 1/60 in. diameter.

Mr. Watermeyer states that I assume the greatest error to be feared is dependent on the fineness of the crushing, whereas in his opinion it depends on the quantity crushed, and the proportion thereof taken for assay. I tried to show it would be influenced by both factors, and, other things being equal, would vary inversely as the square root of the weight of sample taken.

His contention that the gold would be absorbed by the lead, irrespective of its being fine or coarse, may be granted, but obviously unless the correct weight of gold were present the result would be inaccurate.

Sample Crushers.—These are admittedly slower than a disc pulveriser; we can crush about 80 ore samples per day with eight (double) mills. On the other hand, they are cheap, and it would be easy to add to their number. Some of them have been in daily use for a year, no repairs or renewals have been required, and their efficiency is unimpaired. Wear is confined almost entirely to the cast iron casing and balls, both of which can be cheaply renewed. Their being nearly noiseless, and, except when cleaning, quite dustless, are points in their favour. They take the product of a laboratory "cracker"; if fed with finer material, say, 8 mesh, they would be quicker.

Fluxes.—At Mr. Watson's suggestion a list of the fluxes used here is appended. The lead buttons range from 35 gm. to 45 gm. for 1 a.t. charges, 45 gm. to 55 gm. for 2 a.t., and about 15 gm. for solution assays.

Stibnite in moderate amount gives no trouble here; if too much is present there is the usual orange efflorescence, and characteristic swelling of the cupels with low results. Preliminary scorification of the lead button usually rectifies matters. The excess litharge method is used sparingly, being apt to carry gold into the slag.

Furnace.—Some points in the reverberatory furnace criticised by Mr. F. W. Watson are :—

The high bridge, which was adopted to lessen the danger of pieces of fuel getting into the pots when stoking. I have not detected any lowering of the heat efficiency.

The abrupt lowering of the roof.—Two furnaces were previously erected elsewhere, in which the roof was continuous and the bridge lower. The pots next the bridge were less strongly heated than those further back, this is not the case here, and the change has been a decided improvement.

The sloping hearth is required because manufacturers have not yet put on the market crucibles specially designed for reverberatory work. The pots usually have a base only about half the diameter of the top, and while quite suitable for the Cornish furnaces for which they were designed, are top-heavy and easily upset in the reverberatory. With the sloping floor the first row of pots lean against the bridge, these in turn supporting the other rows; thus they cannot fall forward, and owing to the slope cannot fall backward. It is very rarely that we get an upset, and then only through great carelessness.

Furnace too large?—With a smaller furnace perhaps some saving of fuel might be made. The idea of a comparatively large one was to save time and labour. Formerly there were four Cornish furnaces, of which two were in daily use, and two muffle furnaces. By substituting for these the present

combination reverberatory not only was a saving effected in time and native labour, but by using coal instead of the more expensive coke, the cost of fuel was reduced.

Cupellation.—Before adopting cupellation on the reverberatory hearth without a muffle, tests were made to be sure there were no greater losses than by the usual method. Check assays cupelled in muffle and reverberatory gave the same results. Prills of parted gold re-cupelled with lead and silver, again parted and weighed on a balance weighing to 1/100 mg. showed no loss. Some dozens of check assays were sent to a smelter and to two reliable firms of Kalgoorlie assayers, and results agreed extremely well. Many check bullion assays were made, and here there was a slight difference, the reverberatory always being a little higher both in gold and silver, but for bullion work the reverberatory is very inconvenient, and a muffle is to be preferred.

Assay results here compare well with plant returns, thus for the year 1919 the cyanide plant returns were 0·044 dwt. per ton below the assay call, 5 dwt. to 6 dwt. tailing being treated, and for the first six months of this year the agreement is rather closer.

This is the third mine on which I have successfuly introduced this system. Some little experience is required in regulating the fire and draught, but there is no real difficulty.

If under proper conditions accuracy is not lessened by the presence of the products of combustion, it may be possible to design a special cupellation furnace—not necessarily on the lines adopted here, but gas fired, and perhaps usin~ surface combustion.

Cupels.—Unless the cupels are saturated with litharge, no addition is made, otherwise 25% fresh material may advantageously be added to the re-ground cupels. I am glad Mr. Watson called attention to the danger of spitting with cold cupels. I should have mentioned that this is avoided by baking them in large batches in the reverberatory overnight. They are then stored in the furnace room.

Cupel Plates.—Corrosion is little if any more rapid than with the iron muffle plates now in general use. Pieces of scrap, say ¼ in. thick, last fairly well, they need not be cut to any particular size.

Solution Assays.—The opinion I expressed that gold, precipitated from its solution in cyanide, was to some extent re-dissolved on heating was based on my experience that much lower results were obtained by the cuprous chloride method on plant solutions that were precipitated hot than was the case with cold solutions.

I cannot say whether this applies to pure solutions also. Mr. Watson asks why sulphuric acid *must* be used with the chloride method. The reason I do not know, but the fact that the substitution of hydrochloric acid gives low results may be seen from the examples given in Table IV. of its effect on plant solutions. Sulphocyanide was present in all these solutions, and it should be remembered that sulphocyanic is one of the very strong acids (see Jones's *Physical Chemistry*, 4th edition, p. 613). May not this have some bearing on the better results obtained with sulphuric acid in the cuprous chloride assay?

I doubt whether it is generally realised how greatly the accuracy of the copper methods is impaired by the presence of certain impurities. This is more especially the case with the copper sulphate method.

In Table 3 will be found the results of some assays made on solution of pure gold in cyanide, to which definite quantities of impurity were added. After making the assay by the copper methods the precipitate was collected, then the filtrate was assayed by the zinc and lead acetate method to determine the amount of gold that had escaped precipitation by the copper salts.

It will be noted that the combined results seldom give the whole of the gold, there may have been some loss in manipulation, and probably more in cupellation, when much copper was present in the lead button. Comparing the copper sulphate and chloride methods, I have found that on pure solutions the former usually gave slightly higher results, but with increasing impurity its efficiency fell away far more rapidly than was the case with cuprous chloride. To some extent this may be due to the strength of solutions employed, 25 cc. sulphate solution containing 0·64 gm. copper against 1·14 gm. contained in 15 cc. cuprous chloride solution. With the smaller amount of copper cupellation loss would be less, yet there would be an ample excess of copper for pure solutions. With increasing impurity the greater cupellation losses of the chloride method would be more than balanced by better precipitation due, partly, to more copper being present.

There is another, and I think essential, difference. In the one case copper is added entirely in the "ous" state, to which, in

the other case, it all has to be reduced by the cyanogen compounds present and by sodium sulphite. This reduction is often incomplete. Take the fifth and sixth cases in Table 3, the amount of copper added in both methods was the same, yet the chloride was far more efficient, with the other method much copper was present in the filtrate, although plenty of sodium sulphite was added, and care was taken that it was in good condition and unoxidized.

As the zinc and lead acetate method is much less affected by impurities, it would seem unwise to use copper methods for assaying solutions.

I first realised the unreliability of copper methods when treating weathered pyritic tailing. Much sulphocyanide and thiosulphate was formed, and cuprous chloride precipitated only a fraction of the gold. Chiddy's zinc and acetate method was then used and the call agreed with the output. Attention to the matter was called at the time.*

Air Pressure Filter and Samples containing Dissolved Gold.—I cannot agree with Mr. Watson that there is little or no advantage in using this filter. On going rather carefully into the question of losses on pulp containing much dissolved gold, such as that from agitators treating high grade ore without amalgamation, the loss by direct evaporation, no matter how carefully performed, was very considerable; this merely confirmed what was generally known. The loss was reduced, but by no means eliminated, by addition of cuprous salts before evaporating. With residue samples, both the actual and percentage losses were smaller but still important. On 52 samples assayed in triplicate by various methods the best results were got by adding to the pulp an emulsion of freshly burned finely ground charcoal and filtering off the barren solution in an air pressure filter.

On this mine precipitation by cuprous chloride and filtration gives good results. It should be noted that 1 gm. copper as cuprous chloride gives a large excess on residual solutions, and this copper, being distributed over 500 gm. or more residue, causes no cupellation losses.

Evaporation of slime pulp is slow and sloppy, is liable to give low results, and wastes time and fuel in evaporating barren solution that can be removed by the filter in a few seconds.

* Treatment of Weathered Pyritic Tailing, *E. & M. Journal*, 23rd March, 1912.

TABLE I.

2 a.t. sample, value 20 dwt. composed entirely of equal sized spheres.

Diameter of spheres of gold and quartz.	Weight of each sphere.		Number of spheres contained in sample.		Error to be expected.			
	Gold.	Quartz.	Gold.	Quartz.	Number of gold spheres.		Dwt. per ton.	
Inches.	m.g.	m.g.			Max	Mean.	Max.	Mean.
1/400	0·0026	0·00036	778	161,000,000	78·9	22·0	2·03	0·56
1/200	0·02	0·0029	100	20,000,000	28·3	7·8	5·65	1·56
1/100	0·165	0·023	12·1	8,500,000	9·8	2·7	16·17	4·5
1/60	0·702	0·098	2·85	591,000	4·7	1·3	33·0	9·2

TABLE .II.

Fluxes used.

	General about 130 and 220 gm. used for 1 and 2 a.t. ore. gm.	Heavy Sulphide about 130 gm. for 1/2 a.t. ore. gm.	Very heavy stibnite 190 gm. to 1/2 a t. ore, gm.	Solutions, pot assays, 70 gm. taken. Filter paper is the reducing agent.
Litharge	12,000	16,000	150	12,000
Sod. Carb.	20,000	20,000	1/2 a t.	2,000
Borax	8,000	8,000	Light cover	4,000
Mealie Meal	nil to 1,000	—	—	—
Silica	—	6,000	1/2 a.t.	—
Powd. Glass	—	—	—	4,000
Nitre	—	—	10	—

TABLE III.

Effect of impurities on solution assays made by copper methods.
20 a.t. solution taken for assay.

Contents of solution.				Gold precipitated				Copper required to combine with all cyanogen compounds present "J"	Copper added as Cu_2Cl_2	Copper added as $CuSO_4$
Au.	KCy (free)	NH_4CyS	$K_4FeCy_6 \cdot 3H_2O$	From original solution by cuprous chloride method.	From filtrate by zinc and acetate method.	From original solution by cupric sulphate method.	From filtrate by zinc and acetate method.			
dwt.	%	%	%	%	%	%	%	gm.	gm.	gm.
24·60	0·058	0·01	nil	95·4 "A"	—	99·2 "B"	0·8	0·387	1·14	0·64
,,	,,	0·05	,,	92·4 "A"	0·2	58·0 "B"	34·3	0·587	,,	,,
,,	,,	0·10	,,	91·2 "A"	—	44·2 "B"	51·1	0·836	,,	,,
,,	,,	0·20	,,	85·8 "A"	2·1	4·5 "B"	89·8	1·334	,,	,,
23·58	0·219 "H"	,,	,,	96·0 "F"	1·6	14·4 "G"	73·6	2·271	1·52	1·53
,,	0·019	0·50	,,	92·2 "C"	0·4	21·5 "D"	—	2·6	3·2	3·2
						13·4 "E"	59·9	—	—	—
,,	,,	,,	,,	5·6 "A"	93·5	—	—	2·6	1·14	—
24·60	0·058	nil	0·20	95·6 "A"	0·6	96·1 "B"	1·4	1·058	,,	0·64
23·58	0·019	,,	0·50	82·9 "A"	10·8	—	—	1·811	,,	—

METHODS OF ASSAY.

"A" 15 cc. Cu_2Cl_2 solution acidified with H_2SO_4.

"B" 25 cc. of 10 % cryst $CuSO_4$, 10cc. of 10 % cryst Na_2SO_3 and 5 cc. strong HCl.

"C" 42.1 cc. Cu_2Cl_2 solution acidified with dilute H_2SO_4.

"D" 125 cc. 10 % cryst $CuSO_4$ 100 cc. 10 % cryst Na_2SO_3, 10 cc. of 1 to 10 H_2SO_4.

"E" To filtrate added 50 cc. more sulphite solution, which precipitated more gold, then assayed filtrate by zinc and acetate.

"F" 20 cc. Cu_2Cl_2 solution, acidified with H_2SO_4.

"G" 60 cc. 10 % cryst $CuSO_4$, 24 cc. Na_2SO_3 (cryst) 12 cc. strong HCl.

"H" Note the cyanide strength has been increased.

"J" When ferro cyanide is present the amount required is probably less than stated. More than one reaction occurs and the amount given is the maximum.

TABLE IV.

Shewing effect of hydrochloric and sulphuric acids when used with the cuprous chloride method in assaying plant solutions containing sulphocyanides, ferrocyanides, and other impurities.

Method of Assay.	Sample A.		Sample B.		Sample C.		Sample D.	
	Precipitated dwt.	Recovered from filtrate. dwt.	Precipitated. dwt.	Recovered from filtrate. dwt.	Precipitated. dwt.	Recovered from filtrate. dwt.	Precipitated. dwt.	Recovered from filtrate. dwt.
$Cu_2Cl_2 + H_2SO_4$	2·24	0·14	1·74	not assay'd	1·30	not assay'd	1·52	0.04
$Cu_2Cl_2 + HCl$	1.82	0·47	1·29	0·51	1·04	0·26	—	—
$CuSo_4$ &c.	—	—	—	—	—	—	0·78	0·61

The cuprous chloride method was as given in my paper, and in note "A" Table 3.

The cupric sulphate method was as given in note "B" Table 3, the copper being added first, then the acid, and lastly the sulphite, shaking well after each addition.

The filtrates were assayed by zinc and acetate method.

VOTE OF SYMPATHY, RE KNIGHTS DEEP CONFLAGRATION.

The President: At this stage I should just like to express the sympathy of this Society with the directors, staff and workmen of the Knights Deep Mine in the great loss they have sustained by the burning of their mill. This is probably the largest fire that has occurred in connection with any industrial undertaking in South Africa. It is really a serious thing for the whole of the community that lives in that part of the Rand. I am sure I am simply expressing your sympathy when I say how much we feel for them in the great disaster that has overcome that community. (Hear, hear.)

THE GOLD PREMIUM.

By S. Evans (Associate).

(*Printed in Journal, May,* 1920).

DISCUSSION.

Remarks on the Report of the Select Committee on the Embargo on the Export of Specie.

Prof. Edwin Cannan (Professor of Political Economy at the University of London) *(contributed)*: The Committee have failed to arrive at a clear understanding of the mechanism by which the exchanges between the gold-standard countries were kept close to par before the war. They recognise that the movements of gold from country to country had something to do with it, but, either owing to their failure to ask the proper questions, or owing to the weakness of the witnesses in answering, they have not grasped the fact that these movements of gold acted on the exchanges by bringing down the prices of goods and services in the country from which the gold was exported and raising the prices of goods and services in the country into which it was imported.

For example, if in New York the supply of paper giving the holder the right to draw sovereigns in England happened to be so plentiful that the right became appreciably less valuable than $4.86, it was immediately worth while for somebody to exercise his right to draw actual sovereigns in London and bring them out to New York, because each full-weight sovereign could there be converted into approximately 4.86 dollars. Then the tendency of the exchange to fall was checked. But why? Simply because the removal of the sovereigns from England and their conversion into dollars in America tended to reduce the power of people to spend pounds on goods and services in England, and increased the power of people to spend dollars on goods and services in America. In other words, English prices fell and American prices rose. This change made it more profitable than before for Americans to buy English goods and less profitable than before for Englishmen to buy American goods. The fall in exchange was checked by the alteration in the international trade, and further movement of gold became unnecessary.

The failure of the Committee to understand this is made quite plain by their allowing some of the witnesses to induce them to hold up the recent " loss of gold " by the United States as an " awful example " of the danger of going without an embargo on the export of specie. One or two of the better instructed witnesses did suggest that the exportation of the gold was not an evil, but none insisted with sufficient emphasis that it was precisely what was required by the United States in order to stem the rising tide of commodity prices which causes the unrest which threatens to engulf modern civilisation.

Regarding this blessing as a disaster to the United States, the Committee ask if a country with an excess of exports amounting to 4,000 million dollars suffers such a loss of gold, how can the poor little Union of South Africa, with her precarious balance of trade and a "comparatively infinitesimal" stock of specie expect to retain her gold coin without an embargo. Unprotected by an embargo, the Committee believe South Africa, which is producing gold enough to make between thirty and forty million sovereigns a year, will be in "imminent danger" of " being completely denuded of its specie reserves." This fear of " all our gold being drained away " is about as widely spread throughout Europe as the fear of witchcraft three hundred years ago, and is equally groundless, *provided that the gold is not pushed out by paper substitutes.* In the absence of such substitutes each successive exportation of gold raises the purchasing power of what remains very quickly, so that the profitableness of further exportation soon diminishes to nil. We are not terrified by

the fear of losing all our copper or our platinum if a little is exported, nor ought we to be so if a little of our gold is taken by foreigners in exchange for their goods. If they asked for more, they would have to give more and more till they found the trade completely unprofitable.

The Committee themselves see nothing wrong in the annual exportation of gold enough to make 40 million sovereigns when that gold comes straight from the mines and goes out of South Africa unstamped with the King's head on one side and the George and the Dragon on the other. "We do allow raw gold to leave the country," Mr. Strakosch told them, "but it is a commercial product, just the same as wool." When it is once cut into equal sized bits and stamped in a particular way, it is a sacred thing, and if you get it out of banks and export it "you are draining their reserves" (§202).

Supposing that the South African Mint was in working order, as it should have been long ago, and the gold-producers found it convenient to coin the gold before exporting it, would they be forbidden on the ground that raw gold is an article of commerce like wool while sovereigns are reserves which must on no account be exported? It is made clear by p. vii. of the Report that the Committee regard persons who "drain" coined gold from a country as malefactors: they talk of "the inducement to *smuggle* gold coin out of the Union" as something which would exist after the embargo was removed, whereas, of course, what is "smuggling" under the embargo would be lawful and wholesome exportation when the embargo was absent. Who, it is worth while asking, would these malefactors be? At present under the embargo, Mr. Strakosch informed the Committee, "we have not departed from the basis that our currency is worth so many grains of gold. The only unfortunate thing is that there are people who are prepared to pay (for a sovereign) more than the gold in that sovereign is worth" (§84). Presumably what he meant to say was that the unfortunate thing was that there are people who are prepared to pay for a sovereign more than £1 of Union currency, because the gold in the sovereign is worth more than that. If the sovereign can only be got out of the country the East will give a very high price for it. The malefactor who drains away the gold is neither the nefarious Bosch, who is content with unlimited paper marks, nor the pushful Yankee, who is "losing gold," but, "Lo! the poor Indian!" "The premium on gold," say the Committee, plaintively, "is higher in the East than anywhere else." Yet the people who give the best price for South Africa's principal product may surely be reckoned her best customers!

The Committee practically admit that though it is difficult to keep up the stock of sovereigns when the value of £1 currency is less than that of 113 grains of fine gold, there would be no difficulty whatever if £1 currency would buy 113 grains in the market. But, confused by their principal witnesses, they do not see that the way to make £1 worth as much as 113 grains of gold is to reduce the present quantity of currency. It is surely obvious that if there were no notes at all, and nothing was legal tender for pounds except sovereigns containing 113 grains of fine gold, which could be freely melted and exported, £1 could not possibly be worth less than 113 grains. It is equally true, and nearly as obvious, that as notes are a convenient form of currency, this state of things could be reached by reduction of the notes long before the note-issue was completely extinguished—certainly before it was reduced to its pre-war amount.

I may perhaps be asked: "If this is true, why don't you reduce the note-issue in the United Kingdom and bring Bradburys up to par?" Personally, I have no doubt that this ought to be done, and done quickly. But there is a great obstacle in the way which, happily, is absent in South Africa. This is the large amount of money owed by the British Government and payable at early dates. This is supposed to make it very difficult for the Government to insist on a reduction, as the reduction might be accompanied by a kind of run by the banks upon the State, which it would be unable to meet except by the re-manufacture of paper money. In South Africa the pressure would be only on the banks, and to say that these would be after, say, twelve months' notice, incapable of meeting it with ease or, more accurately, of preventing it from ever being severe, seems to me to be quite absurd. Moreover, if we in England are not reducing our currency as we ought, we have at any rate put a limit on its increase of a much more definite character than any proposed for South Africa by the Committee. Since I began to write an announcement has been made to the effect that the seven per

cent. premium on South African currency as against British pounds (alias Bradburys) has disappeared. This seems the very natural fruit of the Committee s recommendations. So far, the banks have been hindered in their work of depreciating the currency by fear of the smuggler and fear of the embargo being removed at some early date. The Committee has relieved them of both fears, and they can go cheerfully full steam ahead, lending cheaply manufactured money at low rates, not at their own expense, but at the expense of the fixed-income class, the salaried class and the wage-earners, who find the cost of living rise faster than they can get their money-incomes raised.

The process will end some time, of course —with exactly what kind of a bump I will not attempt to prophesy.

Prof. Achille Loria (University of Turin, Italy) *(contributed):* The arguments of Mr. Evans seem to me unanswerable. There is no doubt that inflation has been the principal cause of the upward movement of prices, and of the premium on gold, and—as money wages do not go up at the same rate as prices—of the diminution of real wages. I am all the more glad to find that thesis in Mr. Evan's paper, as I myself defended it in lectures at the Milan High School of Commerce, which were recently published in my booklet "The Money Intercourses of War" (1920). It cannot, however, be maintained that inflation alone has been the cause of that phenomenon. Who, indeed, could deny that the upward movement of prices has been in part the result of the diminished production consequent on the war; or, that the gold premium has been sharpened by the excess of imports over exports and the resultant unfavourable balance of payments; or, again, that the diminution of real wages arose also from the absorption of the national capital by public debts, and—after the Armistice—from the increase of the labour supply caused by the return of soldiers from the colours? But all these elements cannot compromise the substantial soundness of Mr. Evans's views, and, above all, of the remedy he is so warmly advocating, namely, the gradual reduction and final suppression of redundant paper money. This, indeed, should be the starting point of every State policy directed towards the economic reconstruction of the belligerent world.

I would add that, in my view, inflation embraces not only bank and Treasury notes, but also deposit currency, *i.e.*, cheques.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Estimation of Metallic Zinc Content of Zinc Dust.—1 gram of zinc dust is put into a 600 cc. Erlenmeyer flask, together with 50 grams of ferric alum in crystals and 100 cc. of water, the whole being constantly stirred. As soon as the zinc dust is dissolved, 100 cc. of 1 :10 sulphuric acid are added, and the solution titrated against potassium permanganate Comparisons of results obtained on new and used zinc dust by the hydrogen-gas method and the ferric alum method are given, and show good agreement.—W. F. Edwards, *Chem. and Met. Eng.*, 1919, 21, 192, *Jour. Chem. Soc.* Abstracts, Nov., 1919, ii. 478. (H. R A.)

Rapid Estimation of Nitric Acid.—When nitric acid is added to a solution of ferrous sulphate acidified with sulphuric acid, oxidation of a portion of the salt occurs, accompanied by formation of nitric oxide, which yields the intensely brown additive compound with the excess of ferrous sulphate; on further addition of nitric acid, the colour disappears as soon as the ferrous sulphate is completely oxidised: $6FeSO_4+3H_2SO_4+2HNO_3=3Fe_2(SO_4)_3+2NO+4H_2O$. The discharge of the colour is sufficiently sharp for the process to be applied to the volumetric estimation of nitric acid. The solution of ferrous sulphate contains 66·66 grams $FeSO_4,7H_2O$ per litre, and is standardised by permanganate; 10 cc. of this solution are heated with 50 cc of sulphuric acid (60–66 Bé.) and titrated with the nitric acid under investigation until decolorised.—Lucien Mauge, *L'Ind. Chim.*, from *Jour. Chem. Soc.* Abstracts, Oct., 1919, p. 425. (H. R. A.)

Iodometric Estimation of Arsenic Acid.—The reaction $As_2O_5+4HI=As_2O_3+2I_2+2H_2O$ proceeds from left to right only in strongly acid solution. Accurate titration results are obtained for arsenate concentrations of $N/5$ to $N/10$ with a minimum concentration of hydrochloric acid of $4N$ in the mixture. For more dilute arsenate solutions ($N/50$), a minimum hydrochloric acid concentration of $4·5N$ is required. After addition of the iodide and the acid to the arsenate solution, five minutes must elapse before titration with thiosulphate.

Molybdate, tungstate, vanadate, manganous, ferrous, uranyl, and chromic ions appear to have no catalytic effect on the reaction.—I. M. Kolthoff, *Pharm. Weekblad*, from *Jour. Chem. Soc.* Abstracts, Oct., 1919, p. 684. (H. R. A.)

METALLURGY.

Some Notes on the Operation of a Portland Continuous Filter in Costa Rica, Central America.—"It should be noted that the material treated averages only 6·5% coarser than 100 mesh. However small the hole which develops in the filter medium, a certain amount of grit goes through the valves and vacuum pumps. On the other hand, classification to slime without grit, cuts down the capacity of the filter and runs up the dissolved values in the tailing.

Equipment.—A unit includes one 7½ x 12 ft. Portland filter; 6 in. x 6 in. American air compressor; 4 in. x 4 in. Connersville rotary vacuum pump; air receiver, motor, etc.

Operating Data.—(1) The conditions held: 10 lb. air is maintained in the receiver; 15 to 20 in. vacuum is carried on the pump, depending upon state of wear of the pump and valves. The vacuum pump for 4½ years lifted the solution to a height of 9 ft above the level of the centre of the pump. The pressure has since been taken off the pump, because it would not give the required vacuum nor perform the lift on account of wear; 2 to 5 lb. air pressure is carried in the discharge pipes of the filter.

(2) The tonnage treated averages 991 tons dry material per month.

(3) The slime of 1·456 specific gravity (sp. gr. of dry ore is 2·63) is treated by filter. Screen analysis of the material treated averages:

	Per cent.
On 80 mesh	2·5
On 100 mesh	4·0
On 150 mesh	6·5
On 200 mesh	5·0
Through 200 mesh	82·0

(4) 8 to 13 gallons of solution is discharged by vacuum pump. This depends upon the state of the filtering medium.

Only one solution product is made.

(5) The dissolved value in the tailing runs $0.03 to $0.05 per ton of dry slime.

(6) The tailing is sluiced to the river.

(7) The average total cost of filtering, including operation, repair, maintenance, but not power nor superintendence, is $0.028 per ton filtered.

Life of Various Parts.—Thirty-five hours are required to recover the filter. This includes taking off the old wire, cloth and burlap, removal of all screens and cleaning by hand, sluicing out of solution pipes, re-assembling, recovering and rewinding. Valves, gears and the pump are always gone over carefully and the necessary repairs made.

(1) The life of the valve plate and seat averages 4½ years without regrinding or scraping. The life thereafter depends on the skill of the mechanic.

(2) The life of the hose from the valve plate—no replacements.

(3) The life of the vacuum pump on this duty is about five years. Impellers and case become worn by sand, and pinions wear out.

(4) The valves of the air compressor last about four years.

(5) A new soft iron scraper, to remove the tailing, is replaced about every four months.

(6) A filter cover lasts eleven months. One set of burlap undercovers lasts twenty-two months.

(7) The wire winding is generally changed with the cover, though on two occasions it was used over with no trouble except in rewinding.

(8) The main driving gear lasts three years.

(9) The main driving worm lasts thirteen to fifteen months.

(10) The main driving gear and pinion—no replacements.

(11) After five years the wooden parts showed no deterioration except a few worm holes which were stopped with tar and rosin. Those holes were made during a two months' shut-down."—H. H. Juchem, '10.—*The Colorado School of Mines Magazine*, April, 1920, p. 69. (H. A. W.)

MINING.

Mine Shaft Signalling.—In 1913 representations were made by some Scottish Trade Unions to the English Home Office on the subject of visual signalling in coal mines, and regulations are now in force to make the adoption of visual signalling devices compulsory in all mines of the United Kingdom.

With the exception of one or two signals such as 1 to start and 1 to stop (when in motion) there are no signals which are used commonly amongst the mines, and some difficulty has been experienced in carrying on the requirements of the regulations. Many devices have been invented for visual signalling, but most of these depended on the human element of the engine-driver tripping the pointer back to zero by hand or by a pedal operated mechanism after each signal. Other mines have gone much further and installed a more elaborate luminous system, with a device for cancelling automatically the signals from off the engine.

It was soon found desirable to reduce the human agency in the cancelling of signals, and the simplest form of complying with the act was then reached, namely, a dial-indicator, the pointer of which automatically registered the nature of the signal, and a cancelling device operated from the engine to cancel the signal when the engine is moved to comply with the order.

The drawback to this simple system, however, is so-called cumulative signals. With very few exceptions the dial indicators were so constructed that the pointer moved one step round the dial for every stroke of the bell, irrespective of the pause between the strokes, and the only way to return the pointer to zero was the movement of the engine which operated the cancelling device. Consequently when the signal 3 for "men on" was given, followed by one to raise, or two to lower as the case may be, the pointer would first stand at the first position and then proceed to the second signal round the dial and finally rest at position 4 or 5.

Another difficulty that arises from the use of this device is that repeat signals are often given. When delays occur either at the surface or underground, repeat signals are often exchanged between the signalling parties. If the delay continues, and signals are exchanged, the pointer goes on proceeding round the dial, and thus any signal may be finally shown. The abolition of repeat signals is unworkable, and would be productive of great delay.

There are many ingenious methods of overcoming this trouble with electrical aparatus, and probably the simplest consists of a lever that hangs below the switch, and which must be raised before pressing the button home to give the signal. Should the signal consist of a number of strokes the lever must not be allowed to fall back into its original position between each stroke, but is withdrawn a short way and only allowed to fall back when the signal is complete. Immediately the operator

removes his hand the lever is returned to its off position by means of springs, and has to be turned again before giving another signal. In this switch it is the raising of the lever in the first operation that cancels any proceeding signal.

In dealing with a mine with a number of levels the regulations require an arrangement by which the level that is sending is shown usually on separate instruments or dials in the engine-room. One good method of dealing with this question electrically is by placing the banksman in charge of the signals and then by means of a switch connecting up to the stations as desired. This prevents confused signals being transmitted to the engine-room. The device for automatically cancelling the signals when complied with by the movement of the engine has received a great amount of attention on account of the particular duties it has to perform, and many clever devices have been developed.

It is distinctly stated in the Act that action signals must remain on the indicator until complied with, but compliance does not mean completion. It is advisable that the signal be effaced as soon as the engine-driver sets his engine in motion so as to leave the indicator ready for the "stop" signal. As a matter of fact, it is essential that the displayed signal should be cancelled by the smallest movement of the engine, for quite a large proportion of these stop signals are given just as the conveyance moves away. Again, the cancelling device must clear itself so that the stop signal can be definitely given, and it must operate immediately the engine comes to rest and cancel the stop order, for, if allowed to remain when the engine is at rest, the indication may be taken as "raise."

In some systems the cautionary signals, such as "men on," are retained usually in addition to the action signal to move the cage. It is certainly an advantage that these signals should remain visible until the wind is just completed. For instance, if the signal "men on" is given, the indicator remaining visible until the completion of the trip is an additional safeguard, as the driver has it before him during the whole time the men are riding.

Again, if the indication is an instruction to proceed to a pumping station, it certainly seems desirable that the signal should remain visible till the cage has arrived at the landing place.

Space will not permit of a detailed description of the numerous systems now in use. They may, however, be summed up under two headings—(1) Apparatus of a step-by-step motion, which can be used in conjunction with mechanically or electrically operated devices; (2) Apparently of a more elaborated type, generally giving luminous indications which are invariably electrically operated under the first heading are quite a large number of various types of dial indicators, and the majority of these are fitted with a relay device. Another form has a straight strip of metal a few inches in width, which is raised by a step-by-step motion. The orders are painted on the strip, and appear through an opening in the front plate of the instrument. Another type consists of an actuating magnet, whose armature, fitted with a pawl, engages a ratchet on the spindle of the pointer, and turns it one tooth for every impulse or signal. The armature of another magnet forming the releasing mechanism engages the same ratchet wheel to keep it in position. When the magnet is energised the armature disengages the ratchet, and the pointer is returned to zero by a voluble spring mounted on the pointer spindle. There are no lag-time devices fitted to the indicator, but cumulative signals are prevented by a special form of sending switch, which is fitted with a grip handle that has to be turned through 90° in a clockwise direction before it is possible to press it in and give the signal. The first operation of turning the handle operates a pair of contacts in the releasing circuits, and any preceding signal which may be shown on the dial is cancelled before a successive signal is registered. A releasing switch for cancelling all visible signals by the engine is also provided. This switch is of a rotary type driven by a belt from the drum shaft. It consists of a circular aluminium housing, which is revolved and on this arranged radially are 15 tube-shaped contactors, each containing a small quantity of mercury, and contact between the ends is made when the metal is allowed to trickle slowly down from one end of the tube to the other. The releasing circuits are closed at 1/30 of a revolution, and the mercury does not begin to trickle down till the engine is practically at a standstill, so that should a stop signal be given it remains visible till the engine has almost stopped, and then the dial is cleared ready for the following action signal. Luminous attachments can be added to the dial indicators to visibly indicate cautionary signals such as "men on." The engine-driver has now all the signals visualised in front of him, and when the engine is just moving off at the commencement of the wind, the action signals will be cancelled from off the dial, whilst the illuminated cautionary signals will remain until the wind is completed, when these, too, will be cancelled by a special form of governor type switch driven by the engine. —O. D. Kennedy, *Iron and Coal Trades' Review*, April 30, 1920, p. 584. (J. A. W.)

Abstract of Patent Applications.

545.19. Edgar Allen & Co., Ltd. Improvements in apparatus for mixing, circulating and agitating materials in a liquid or semi-liquid state. 14.7.19.

This application relates to apparatus for mixing and agitating materials such as crushed ore, cement slurry, or other finely divided product suspended in liquid.

It comprises in combination a mechanically actuated stirrer and a jet or jets of compressed air or gas.

The tank or receptacle in which the apparatus works is provided with any number of stirrers (three being shown in the drawings), each of which is mounted on a vertical spindle (hollow), the spindle being adapted to be driven by means of pinions upon a driving shaft meshing with bevelled wheels upon the spindles in the usual way.

The compressed air or gas is led through the hollow spindle to distributing tubes mounted upon the stirring arms situated near the bottom of the tank. The effect obtained is a two-fold agitation which is beneficial and efficient for the treatment of the products for which the apparatus is intended.

808.19. H. S. Potter. An improved detachable shank for drills, bits, or steels used with "Jack-hammers" and like hammer drills. 1.10.19.

This application states that it is exceedingly difficult, when small diameter steels of high carbon content is used to forge on the steel in the requisite

position a collar of adequate size and also a shank sufficiently large to withstand the impacts of the hammer piston. Also that unless great care is taken in the forging of square shanks from round steel, the finished article is of irregular shape and frequently tapers.

The applicant proposes to overcome these difficulties by making the drill in two parts, viz., the drill proper and the shank, joining the two by a taper on the steel which fits into a socket in the shank. He claims several advantages for this construction, and proposes to form the shanks from square or polygonal section hollow steel

1080.19. C. Gronon. Improvements in and relating to diamond washing machines. 22.12.19.

The application relates to the separation of precious stones by means of a sieve submerged in water, such sieve being actuated in an upward and downward direction by mechanical means. The principle is identical with that known as "hand gravitation," which is the method of concentration commonly employed by prospectors and alluvial diggers, only, in the case of this application, the sieve is mechanically operated and provision is made for feeding the material to be treated on to the sieve through a hopper, and arrangements made for the removal of the discarded matter by means of a dredger or some similar device.

72.20. W. E. Nettle and others. Improvements appertaining to reciprocating rock drills for supplying water to the bore-holes during drilling. 28.1.20

This application refers to means of supplying water to hollow drill steel when used with machines of the piston or reciprocating type.

According to this application, an axial water tube is fixed to the back cover of the drill by a suitable "Spud" or other means to which a hose can be attached, and extends forward through an axial bore in the rifle bar to an axial hole in the smaller part of the piston (sometimes called the piston rod).

The usual packing to the axial tube for the purpose of preventing leakage of water to the interior of the machine are abandoned, and the same result is accomplished by forming an annular chamber around the axial tube where it enters the small part of the piston, and maintaining a supply of air under pressure in this chamber. For the latter purpose a fine hole is bored to this chamber from in front of the piston, through which air gains access to the chamber on the return stroke, and the axial tube is made a slack fit in the rear end of the chamber so that air can leak forward into the chamber on the forward stroke.

The application also mentions that it is desirable to so control the supply of air and water to the machine that at the commencement of drilling air is turned on before water, and at the end of drilling water is turned off before air.

346.20. Minerals Separation, Ltd. Improvements in or relating to the treatment of minerals containing coal. 8.4.20.

This application relates to improvements in the separation of coal from coal-bearing material.

The particular features are the application of the froth flotation process with a modifying agent, such as sodium silicate, sodium carbonate, etc., which effectively wets the gangue, and also a frothing agent such as cresol or the like. Also a non-soluble agent, such as paraffin oil, also the use of sea-water or the like as a frothing agent.

352.20. The Jeffrey Manufacturing Co. Improvements in excavator and loader. 10.4.20.

This application is for a patent for a portable machine to be used for picking up material stored in piles, or excavating it from natural deposits elevating it and loading it into a bunker or vehicles.

383.20. The Skinnigrove Iron Co., Ltd., and Ernest Burry. Improvements relating to the recovery of valuable products from gases evolved in the destructive distillation of coal, shale, and so forth. 19.4.20

The tar, sulphate of ammonia, napthalene and benzol are obtained by means of the usual apparatus and method, but the special features in connection with the application consist in arranging the plant in such a way that the heat of the gases may be utilised in obtaining the products sought. Further, the sulphur from the gas is obtained and converted into sulphuric acid and used on the plant. obtaining alcohol by scrubbing the gases with 95% sulphuric acid to extract the olefiants, the sulphuric acid being also used in obtaining sulphate of ammonia.

414.20. Manoim & Rosenberg. Improvements in safety-arresting devices for mine skips and like conveyances. 29.4.20.

This application relates to safety attachments for mine skips and the like, such safety attachments being of the kind in which wedge devices are arranged to engage with and grip the rails or guides upon breakage of the hoisting rope, or of the parts which attach said rope to the skip body, such as the rail.

415.20. Manoim & Rosenberg. Improvements in man hoisting conveyances for mine shafts 29.4.20.

This application states that the object is so to construct the conveyance as to minimise shock to the occupants upon the conveyace stopping suddenly, as, for example, when arrested by its safety catches or upon meeting an obstruction.

According to the application the conveyance consists of an outer shell or frame carrying the wheels or slippers and an inner body arranged within the shell to carry the passengers, the said inner body being arranged for longitudinal movement in the outer shell and resiliently supported in a mid position therein by springs arranged between the ends of the body and the ends of the shell.

425.20. A. S. Thomsen and E. L. Ramsden. Method of manufacturing and erecting houses with hollow walls. 30.4.20.

The application concerns houses built of concrete. The house is built of a framework of reinforced columns and beams which are manufactured at a factory and in a finished state and are transported to the place of erection, where they are built together in skeleton form, into which are placed panels of concrete slabs, and these, together with the framework, form the outside walls of the house. The panel slabs are made of concrete, covered outside with a water-proofing material, and are provided with tongues and grooves. The columns are provided with grooves only, and thus slabs and columns form a strong and solid construction.

The making of hollow walls is provided for. The main idea is that such a house in all its essential details is manufactured at a factory, and may be quickly and easily erected at any desired place.

There are three claims.

The first claim principally sets forth that the concrete details of the house are shop-work

The second claim is in connection with providing of a hollow space in the walls.

The third claim is in connection with the arrangements for providing the columns and panels with grooves and tongues for the purpose of quick and solid erection.

A drawing accompanying the specification sets out the methods by which the process is carried out.

426.20. A. S. Thomsen and E. L. Ramsden. Method of building walls of clay, concrete, or cement mortar. 30.4.20.

This application refers to a method of building walls of clay, concrete or cement mortar, and the claims refer to the utilisation of wooden laths with nails projecting a certain length and placed at suitable distances, using a form wherein a solid mortar wall may be pressed or stamped, maintaining a constant rectangular volume.

432.20. J. A. Yule. Improvements in or relating to percussive rock drills. 4.5.20.

This application states that hitherto it has been proposed in connection with percussive and other drills to provide a drill comprising layers of different degrees of hardness, the layers being welded together by fusion or rolling, the object being to reduce the cost of materials and to avoid the necessity for frequent resharpening.

The characteristic of the present application resides in the feature that the layers are welded together electrically.

Several forms of drill bit are described, all of which are made on substantially the same principle, namely, alternating layers of hard and soft steel electrically welded together. It also mentions the use of air-hardening steel for the hard layer, and describes soft layers made of denuded sections such as expanded metal, or special stampings, the object of which is to leave a larger proportion of the hard steel projecting as the bit wears.

434.20. E. S. Pettis. Decanting and agitating apparatus. 6.5.20.

This application is for an apparatus patent for a decanting and agitating machine adapted to be used in the wet treatment of ores and the like.

The apparatus embodies the principles of gravity settling and separation of liquids from solids by decantation. It consists of a tank, a rotable conduit member mounted on a hollow shaft, an extension conduit member connected and rotatable in unison therewith; the combination being for the purposes of thickening and decanting the settled slime.

Means are provided for reversing the functions of the combinations, whereby the machine becomes alternately a settler or agitator as required.

437.20. M. A. Barber. Improvements in or relating to pipe unions. 6.5.20.

This application refers to couplings used for pipes and hoses substantially of the kind frequently referred to as "cone couplings," in which a taper spigot portion makes joint with a taper socket portion, the two being drawn into close contact by screw or other means. Tightness being generally obtained by grinding the surfaces which make contact.

The application consists in fitting a resilient packing ring to the socket portion. In cross section the shape of the packing ring is the frustum of a wedge to prevent falling out and risk of loss, the socket being suitably shaped to hold it.

In addition to the taper on the spigot member making contact with the packing ring, there is also a flange on the spigot which contacts with the packing ring and compresses the same as the joint is screwed up.

448.20. C. Keen. Improvements in and appertaining to the construction and erection of concrete building and the like. 8.5.20.

This application refers to the construction of concrete buildings and particular methods of forming the joints in walls and to a procedure with regard to the method of securing door frames, windows, etc., as described and illustrated by accompanying drawings.

500.20. H. A. Williams. Improvements relating to utilisation of combustible gases for heating furnaces and other purposes. 27.5.20.

This application is intended to apply to heating by combustible gases generally for furnaces or other purposes, the novelty claimed being the provision of a temporary check or resistance to the flow of the gases as they leave the zone to be heated, the principal object of which is to obtain a higher temperature.

By way of illustration, the heating of a crucible gas furnace is described, in which after the combustible gases leave the chamber containing the crucible, they are led through a water seal, there being the usual apparatus for indicating and regulating the pressure.

Changes of Address.

Beatty, J. W. S., l/o Randfontein: King's Hotel, Vogelfontein.

Bell, H. C. F., l/o Pilgrims Rest: Nourse Mines, P.O. Box 32, Denver.

Brown, H. J., l/o Hatton Garden, London: c/o Messrs. Johnson, Matthey & Co., Ltd., Patricroft, Manchester, England.

Cullen, Wm., London address:—612, Salisbury House, London Wall, E.C.

Lloyd, J. J., full address: Mines d'Ankitokazo, Autonome d'Ambilobe Par Diego Suarez, Madagascar Nord.

Mackay, A. N., l/o West Byfleet: The Corners, Horsham, Sussex, England.

McNeil, Wm., l/o St. Leonard's-on-Sea: 1, London Wall Buildings, London, E.C.2.

Neal, W., l/o Montreal: El Favor Mining Co., La Quemada, via Magdalena, Jalisco, Mexico.

Pirow, H., l/o Pretoria: P.O. Box 1072, Johannesburg.

Swinney, Major L. A. E., from Active Service: Gopeng, Perak, Fed. Malay States. English address: "Ashland," Wonersh, near Guildford, Surrey.

Thomas, J. E., l/o Johannesburg: 656, Currie Road, Durban

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Proceedings
AT
Ordinary General Meeting, 16th October, 1920.

The Ordinary General Meeting of the Society was held in the University College, Johannesburg, on Saturday, 16th October, 1920, Mr. J. Chilton (President) in the Chair. There were also present:—

13 Members: Messrs. F. W. Watson, J. R. Thurlow, J. Hayward Johnson, E. Pam, John Watson, H. A. White, J. A. Woodburn (Members of Council), W. Beaver, R. R. Kahan, T. R. Ness, H. Pirow, J. W. Travers, and H. R. S. Wilkes.

5 Associates: J. A. Boyd, J. Cronin, O. A. Gerber, J. Gibson, H. Rusden, and H. A. G. Jeffreys (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 18th September, 1920, as recorded in the September *Journal*, were confirmed.

NEW MEMBERS.

Messrs. J. R. Thurlow and F. W. Watson having been elected as scrutineers in connection with the ballot for the election of new members, the following were declared unanimously elected:—

Geddes, James Gordon, P.O. Box 62, Penhalonga, Southern Rhodesia: Mine Surveyor.

Meyer, Charles Edward, P.O. Box 101, Crown Mines, Johannesburg: Metallurgical Chemist.

General Business.

MINING EXHIBITION.

The President: It is proposed to hold the Fifth Chemical, Metallurgical and Mining Exhibition of the Society in Johannesburg from Wednesday, the 9th, to the 16th March, 1921 (both days inclusive).

The purpose of the Exhibition is to bring before the public the latest developments and improvements connected with those subjects which fall within the scope of the Society as implied by its title, and the Council hopes that members and others interested will accord their heartiest support and co-operation with the object of ensuring the success of the Exhibition.

It is hoped to secure the use of the Drill Hall, Union Ground, Johannesburg.

Further particulars will be announced shortly.

MINE AMBULANCE COMPETITIONS.

The President: The Eighth Annual Mine Ambulance Competition for the Surface and Underground Workers' Shields (presented by the Chemical, Metallurgical and Mining Society of South Africa) will be held on Sunday, the 17th October, 1920.

Both competitions will be held, by kind permission of the Directors and Manager (Mr. S. Beaton) at the Nourse Mines, Ltd., which is situated close to Denver Station.

Those interested in first-aid are cordially invited to be present, but the accommodation underground is limited and not suitable for ladies.

VISIT TO KILLARNEY.

The President: I desire to move a hearty vote of thanks to the Directors and Management of the African Films Production, Ltd., for their invitation to Killarney last Tuesday, where a very pleasant afternoon was spent. The visit was in the nature of a preliminary one by your Council with the object of finding out if it would be possible to arrange a visit open to all members.

It is anticipated that at a later date the whole of the Society will be invited to Killarney for an afternoon's excursion.

Mr. John Watson *(Member of Council)* seconded the vote of thanks.

CONGRATULATIONS TO COL. SIR W. DALRYMPLE, K.B.E.

The President: I am sure you will all join with me in congratulating Col. Sir W. Dalrymple on the honour which has been conferred on him recently of Knight of the Order of the British Empire.

NOTES ON THE INFLUENCE OF SOLUBLE SILICA AND CALCIUM SALTS ON PRECIPITATION.

By J. Hayward Johnson (Member of Council).

My object in submitting these few notes is to provoke discussion on a subject of perennial interest, rather than to present anything novel. Until assurance can be felt of obtaining perfect precipitation of the gold under all the varying conditions resulting from changes in the natures of ore and water supplied, the subject should be one of interest to the cyanider. I am of the opinion that the pooling of experiences by discussion might bring us nearer the ideal assurance suggested.

Much has been said in time past on the need for effective clarification of slime solution, but I do not remember having heard any reference to the effect of the soluble or colloidal form of silica, which is capable of passing clarifiers and causing trouble in the precipitation as well as in the filter presses at clean-up. Yet this trouble is by no means uncommon, especially on mines where much reclamation is being carried out.

The following occurrences that have come under my notice during periods of poor precipitation will no doubt be of interest:—

A deposit found on the zinc in the sand solution precipitation boxes;

A scum found at the head and between compartments of sand solution precipitation boxes;

Mr. C. Toombs kindly analysed this deposit and scum for me, reporting as follows:—

"The sample of deposit and metallic zinc received was stirred with water and the deposit decanted away from the metal until as much zinc as possible was eliminated. The purified deposit was dried and analysed with following results:—

Calcium Oxide	26·4%
Carbon Dioxide	18·0
Zinc Oxide	9·0
Sand, etc., insoluble	0·8
Combined water	18·0
Soluble Silica	22·8
Sulphur as Sulphate	0·7
Sulphur as Sulphide	1·0
Magnesium Oxide	0·9
Iron Oxide	1·1
Gold and Silver	0·22
Organic Matter, Lead, etc.	Traces

"The deposit is therefore practically composed of calcium carbonate and gelatinous silica containing water. The mixture is very readily soluble in dilute acids, but if the solution be heated—neutralised, etc., the colloidal silica at once assumes the gelatinous form and is deposited.

"In the absence of further information, it is not possible to determine the origin of the silica, which forms an impermeable coating on the zinc and prevents precipitation. However, if the solutions entering the boxes are perfectly clear, it is apparent that the silica must exist in the colloidal "sol" form and be deposited on the zinc in the "gel" form by chemical or galvanic disturbance."

Scum from Precipitation Boxes.

"This material is practically the same as that found on the zinc shavings—consisting of calcium carbonate and colloidal silica mixed with a little wax. The latter is probably derived from candle grease and is the cause of the flotation of the scum."

The turbidity of slime solution after 24 to 48 hours' settlement (KCy 0·005% CaO 0·008%) is due to silica in a very fine state of division (presumably colloidal suspensoids) which was not removed by sand clarifiers. An examination of this solution reveals the following:—

Matter in suspension		0·0095%
consisting of		
Silica	0·0083%	
Iron and alumina	0·0004%	
Lime	Trace	
Magnesia ...	0·0005%	
Silica in solution		0·0050%

This turbidity remained in the plant for a period of about seven days, but did not show itself in every charge treated during that period.

The make-up water used in the reduction plant was obtained from a dam which received part of its water from a valley into which the drainage from several old sumps, slime dams and the compound was delivered, and contained.

	Parts per 100,000
Total solids dried at 100° C. ...	87·5
Loss on ignition	21·6
Chlorine	2·4
Free sulphuric acid (H_2SO_4) ...	4·9
Combined sulphuric acid (SO_3) ...	40·4

Examination of ignited solids:—

Silica and insoluble	2·3
Oxides of iron and alumina ..	2·3
Oxide of calcium	13·0
Oxide of nickel	2·7
Oxide of magnesium	3·6

Also present small traces of lead and some manganese (included as lime).

Approximate composition of solids:—

	Parts per 100,000
Free sulphuric acid	4·9
Silica (silicic acid)	2·3
Ferrous sulphate	4·3
Nickel sulphate	5·5
Calcium sulphate	31·5
Magnesium sulphate	10·8
Sodium sulphate	22·6
Sodium chloride	3·9

This water carried a considerable amount of organic matter, which is included in the loss on ignition.

Two samples of so-called "white precipitate," one from the East Rand and one from West Rand, showed on examination that they carried 37·95% and 38·75 silica, respectively, which was found in a very fine state of division, almost gelatinous.

I think the above fairly demonstrates that colloidal silica has quite a considerable effect on precipitation, and when the occurrences spoken of above appeared, considerable trouble was experienced in the filter press, the silica forming on the filter papers in a gelatinous film, almost impervious to water, and causing a rapid rise in pressure on the press.

Excessively burnt lime, when the limestone carries an amount of silica, is also responsible for the introduction of soluble silica into the solution. A sample of such lime, on analysis, contained:—

	%
Silica	10·60
Soluble silica	5·43
Iron and alumina	2·35
Lime	64·84
Magnesia	7·20
Carbon dioxide	7·50
Combined water	2·05

The excess alkalinity in the solution circuit is well known to have a detrimental effect on precipitation, and this excess is sometimes caused by the slow solubility of the lime as indicated by the following example:—

Mill water, 0·006% CaO.

Drainage from sand settlers filled during same period, 0·008% CaO.

KCy solution from same sand, 0·046% CaO.

The deleterious influence of the sulphates and of carbonate of lime is no doubt due to the formation of protective coatings on the zinc. Regarding the sulphates, the trouble does not develop apparently until the point of saturation is reached (256 parts per 100,000), when it becomes rapidly acute. The use of the condenser circuit of the steam plant as "make-up" water, though the circuit water is valuable on account of its available heat during the winter months, is, owing to its prior concentration, very liable to develop this point of saturation, in conjunction with the neutralised acid salts of the ore. With the large amount of reclamation work being carried out on many mines and consequent treatment of partially oxidised ores, the amount of calcium sulphate in solution tends to increase, and during the long winter drought usually develops trouble. The cyanider welcomes the breaking of the drought, I fancy, quite as much as the farmer.

I hope that any discussion on these brief notes will not be confined to the few points raised, but will be extended to other observed influences that affect the precipitation of gold on zinc.

In conclusion, I must thank Messrs. Maxwell, Toombs, Whitby, and Edward H. Johnson for assistance given me in collecting much of the above data.

Mr. J. R. Thurlow *(Hon. Treasurer)*: I should like to move a hearty vote of thanks to Mr. Hayward Johnson for his very useful paper on this interesting subject.

As regards some of the analyses and figures given, I feel sure there will be plenty of discussion on these, as I see there are present several able exponents of chemical reactions, and I will leave this side of the matter to them.

Mr. Johnson is only giving the subject a start. He has very kindly given us some points from his own experiences, and to some extent I think his results are fairly general. There are some points, however, on which we, I myself, for one, shall not agree with him.

Regarding the statement that excess of alkalinity invariably causes trouble in precipitation, my experience is that it does not always cause trouble; there are exceptions, more particularly wherever you use zinc dust, but also occasionally where zinc shavings are used it is found that better precipitation follows with an excess, or what is understood to be an excess in local practice, than when using a normal alkaline content.

I wish to express the hope that a result of this paper will be that one of our scientific observers will investigate this particular aspect of the case, as I feel sure the result would prove a fruitful source of discussion and be of considerable value to the mining industry.

Mr. F. W. Watson *(Vice-President)*: I have much pleasure in seconding the vote of thanks to the author for his interesting paper.

Mr. Johnson has mentioned the matter of calcium sulphate in the make-up water from the valley, and I think he is fortunate in only having 40·4 parts per 100,000 combined SO_3. I have had some experience of waters, used in reduction works, that have been practically saturated with calcium sulphate, and, owing to evaporation, this has been thrown out of solution and interfered with the precipitation in the zinc boxes. I can quite understand that soluble silica may have been formed by decomposition of ore which has been lying underground for some time before being crushed. This might be taken up by excessive alkalinity and again thrown out of solution, and deposition of this colloidal body would doubtless impede precipitation of the gold.

The sulphate of lime problem is a very pressing one in some cases, as it is impossible to reduce the amount in solution except by the employment of sodium carbonate, an expensive process.

I hope at a future date to submit further remarks on this useful paper when I have had time to give it the consideration it merits.

Mr. H. A. White *(Member of Council)*: I think this is a very valuable and very welcome paper, as it introduces the subject of the chemical treatment of banket ore, a matter which, I think, has been rather neglected in the Society for some years.

Mr. Johnson has practically confined himself to ore recovered in reclamation work: but there is one aspect of reclamation work now being carried on for which this Society is more or less responsible.

A short while ago Mr. Watermeyer read a paper here on a method of discounting the value of gold ore as obtained from development samples, in order to make results agree better with the gold which is returned by the reduction plant. During the discussion of that paper I myself suggested that gold was possibly left in the stopes and that stope sweeping was not kept up to date on most mines. Mr. Payne followed on about a month later, and demonstrated that a considerable portion of the discrepancy in the gold called for by stope sampling and not at once recovered was due to the fact that a large value remained in the stope sweepings, a value about twice as high as the average screen sample. The facts quoted by Mr. Payne led to quite a lot of underground investigation on the Rand, especially along the East Rand, and they have discovered in many stopes quite a considerable amount of ore, which has been lying there for years in some cases. This ore, having been sampled and found fairly rich, has been hurried into the reduction plants. Now, in many cases, but not in all, considerable trouble has arisen in consequence of that ore being sent up. That ore being oxidised, has invariably sulphuric acid developed in it and, in accordance with the form of pyrites which may be present, you may have, in addition, ferrous sulphate and colloidal sulphur. Excluding the colloidal silica which Mr. Johnson has mentioned derived from interaction of sulphuric acid and silicates present, most of the troubles arising from these sources are not felt so much in the precipitation plant as in the dissolving plant. Furthermore, on some mines rock that has been dumped on the surface for long periods is sent to the mill. In such cases you will have a very similar effect to that caused by allowing the

ore to lie in the stopes for some months exposed to the warm, moist atmosphere, you have these same deleterious substances formed and you have the same injurious effects in the mill and cyanide works; your extractions drop, in some cases quite considerably. After making a lot of experiments on this point, I find that one of the chief difficulties is due to the presence of ferrous sulphate, though this is a readily soluble salt and one would think it would be quite easily washed out of any ore. Also, one would think—and no text-book will tell you the contrary—if you soaked that ore in a saturated solution of lime in excess the ferrous sulphate should be rapidly destroyed. I find that is not the case. In fact, the action between a saturated solution of lime and this ferrous sulphate as it is found adsorbed by the surface of the grains of silica is remarkably slow—in some cases it takes at least two days before the reaction ceases. The natural result when you get a bunch of that sort of stuff in your vat is that the cyanide is locally destroyed and converted into ferrocyanide as rapidly as it can approach the spot, and consequently you are really having no solution of gold till the ferrous sulphate is all gone, with the result that your residues are higher than normal.

Another pyritic oxidation product, colloidal sulphur, is in some cases present to the extent of 2 lb. per ton of ore, and is dissolved out readily in presence of high alkalinity, and the higher the alkalinity the more rapidly is it dissolved out. The sodium sulphide formed simultaneously with thiosulphate rapidly removes any oxygen in its neighbourhood with the formation of further sodium thiosulphate, so that the ultimate result of the reaction is the formation of sodium thiosulphate only, and when this solution gets into the zinc boxes it is very slightly acted upon by the zinc-lead couple, with the result that a zinc sulphide coating is formed. That practically insulates the solution from the zinc, and you are going to get bad precipitation in consequence.

The sulpho-cyanides formed are apparently responsible for no more mischief than the destruction of cyanide. Though the text-books usually deny any reaction with solid sulphur, yet the reaction is fairly rapid when sulphur is present as a colloidal fine suspension. I think most cyaniders are familiar with the fact that zinc sulphide is present in extractor boxes, and when suspended over the acid dissolving vat a piece of lead paper is instantly blackened. The figures given by Mr. Johnson are the first I have seen which show the amount of this substance present.

We can say that one of the principal sources of trouble in reduction plants is the fact that ore is allowed to lie too long in the stopes; or it is heaped up on the surface and is allowed to lie too long there. That is the trouble. In some mines the remedy proposed is the addition of chloride of lime, at something like £50 a ton—or, if it is disguised under some trade name, at £3,000 or £4,000 per ton. The result, I find, of adding chloride of lime in these cases is to make the extraction slightly worse. In any case, it does no good whatsoever. Its use is a sort of superstition; it is one of those superstitions I am always out to fight, if I can. However, I did find a rather unexpected result—that is, if lime up to 20 lb. per ton is scattered over the oxidised and wet material in the stope for at least two days before it is allowed to be removed, and preferably a week—the effect is somewhat remarkable. Slime residues begin to drop at once, and sand residues in due course. The lime slowly gets in its fine work on the ferrous sulphate and on the colloidal sulphur present and removes the principal sources of the trouble, leaving only a remnant to be dealt with by crushing in alkaline and oxygen-saturated solution.

The real remedy is not to accumulate stope-sweepings at all. Every stope must be properly swept up at least once a fortnight; it has been done on some mines, I know, for years, and it should be done in all cases. As a palliation, where you have already broken the law and want to put yourselves right, the only thing to do is to scatter powdered lime over this wet material well in advance of the time it is going to be sent to the mill, sufficient to neutralise all acidity and dissolve all available sulphur.

I would repeat, I think we have to thank Mr. Johnson for introducing this paper, and I hope we shall have a lot of contributions from mines which have dealt with similar material.

Mr. J. A. Woodburn *(Member of Council):* I am sorry I cannot add much from my own experience with regard to the treatment by cyanide of partially oxidised ores, but I know that at Modderfontein Mr.

Spandaw, and at Delmore Mr. Boyd have been treating pyrite carrying about 20 dwt. gold, after being roasted for sulphuric acid, with cyanide, and both claim to get a very high extraction. I suggest both these gentlemen might be asked to contribute, because from what Mr. White says I would infer that the treatment of roasted pyrites carrying small percentages of sulphur must be somewhat similar to the treatment of partially oxidised ore.

A RESUMÉ OF LITERATURE ON THE THEORY OF FLOTATION WITH CRITICAL NOTES.

By H. R. Adam, B Sc., F.I.C. (Member of Council).

(Continuation of Paper printed in Journal August, 1920.)

Since the publication of my paper I have had an opportunity of seeing a contribution to the subject by Irving Langmuir which has recently appeared.[1] Langmuir's work on the constitution of thin oil films[2] and what has been called[3] "The chemical theory of capillarity," has recently attracted a good deal of attention, but whatever the value of his theory may prove to be, it can hardly be said that his present application of it to flotation is very convincing.

It is impossible in a short space to give any detailed account of Langmuir's work, but the general conception may be briefly indicated. It is supposed that capillary effects should be studied not from the view that the molecule is the unit as is usual, but that these effects will depend on the spatial structure of the molecule. Thus in such a case as the spreading of oleic acid on water the COOH groups being the more "active" with regard to "affinity" for water will "combine" with the water while the hydrocarbon groups combine with each other and, being less active, form the real surface layer. "A pure paraffin oil, since it contains no active groups, does not spread on water." "The surface energy of a liquid is thus not a property of the molecule as a whole, but depends only on the least active portions of the molecules and on the manner in which these are able to arrange themselves in the surface layers." With regard to the presence of films of gas or liquids on solids, Langmuir advances similar ideas, thus: "The atoms in the very stable films referred to are clearly held to the surface by direct chemical union of the primary valence type, like that holding oxygen to carbon in carbon dioxide."

In his application to flotation, Langmuir's idea apparently is to give some rational basis in examining the behaviour of different oils. He gives experimental data on the spreading of oils and water on glass, mica and platinum, and also figures for the contact angles of water with various oiled mineral surfaces, found by measuring the dimensions of drops of water on these surfaces. It is also interesting to note that contrary to Sulman's results, "Fresh cleavage surfaces or fractures of calcite, sphalerite, galena, pyrites and magnetite were all readily wetted by water or paraffin oil."

One can appreciate the value of this paper since it indicates possible reasons for the very varying effects supposedly due to different surface energies displayed at solid surfaces, *i.e.*, the effects are assumed to be due to contamination and the nature of the contaminant. A concluding paragraph in the paper referring to the contact angle will, however, be accepted with difficulty by those who have experimented on flotation, viz., "The results indicate that the selective action by which substances like galena are separated from quartz and calcite is dependant upon the contact angle formed by the oiled surfaces rather than by any selective tendency for the oil to be taken up by some minerals more than by others." It is not very clear what this exactly means, but presumably the indications are that all the minerals may have oil films and yet may show varying contact angles. Since the contact angle is after all only an indication of the relative interfacial tensions, one must suppose that although all the particles may be oiled the oil molecules are so orientated on different solids as to produce varying interfacial tensions. Such a conception is quite at variance with the generally accepted statement that the oil preferentially films the sulphide and metallic surfaces.

References.

(1) Irving Langmuir.—*The Mechanism of the Surface Phenomena of Flotation.* Trans., Faraday Soc., June, 1920, p. 62.

(2) For Langmuir's publications see *Journs. Am. Chem. Soc.*, 37, p. 1139 (1915); 38, p. 2221 (1916); 39, p. 1848 (1917); 40, p. 1361 (1918); *Met. and Chem. Eng.*, 15, p. 468 (1916); *Proc. Nat. Acad. Sci.*, 3, p. 251 (1917).

(3) "*The Chemical Theory of Capillarity.*" Wm. C. McLewis, *Sci. Prog.*, April, 1918, p.

THE SOLUBILITY OF ZINC IN CYANIDE SOLUTION.

By H. A. White (Member of Council).

(Printed in Journal, December, 1919.)

REPLY TO DISCUSSION.

Mr. H. A. White *(Member of Council):* Well, gentlemen, the discussion on that paper of mine is something like the case of the snakes in Ireland—absent. Consequently there is no reply. I would, however, remark I do not think it need be any discouragement to any author to publish the result of original researches if he does not get much discussion, because people are naturally shy in coming forward and criticising any results obtained from lengthy experiments unless they themselves have done a fair amount of work.

CAN AMALGAMATION BE DISPENSED WITH?

By E. M. Weston (Member of Council).

(Printed in Journal, February, 1920.)

REPLY TO DISCUSSION.

Mr. E. M. Weston *(Member of Council):* I thank Mr. Neill for annihilating me. I should like to draw his attention to the proceedings of the Institute of Mining and Metallurgy, 1910, and he will learn how at the Ouro Preto mine in Brazil, milling 5,000 tons per month, amalgamation has been profitably dispensed with. The Giant Mine, Rhodesia, milled a larger tonnage per month than this. Mr. Neill is to be thanked for pointing out the printer's error regarding decimal places. In this connection the description placed under Fig. 2 is obviously wrong. This figure, of course, shows a plan and section of the cast iron table proposed. This table might be modified with advantage by placing only a few rows of the upward current sorting devices shown at the top and the bottom of the table, leaving the main area of the table for quiet settlement. With thoroughly wetted particles, I think, should air be used for agitation, which I suggested as a possible alternative for water, the danger of flotation as suggested by Mr. Neill would not be great. With only a few rows of the water agitation devices shown at the top and at the bottom of the table the consumption of water would not be great, and Mr Neill's fanciful objection on this score of the need of filtering and its impossibility need not be considered.

Mr. Neill has not felt himself called upon to answer my question as to why, when methods such as I have suggested are available for recovering the valuable sulphur contents of the ore, it should be considered good practice to send it to the dump.

MEANS ADOPTED ON THE NEW GOCH MINE FOR REDUCING THE CONSUMPTION OF MERCURY.

By H. J. Lee (Member).

(Printed in Journal, February, 1920.)

REPLY TO DISCUSSION.

Mr. H. J. Lee *(Member):* I regret having nothing further to add—the discussion being rather conspicuous by its absence. It seems a pity that more information was not forthcoming from other mines where similar methods have been adopted. I should like, however, to express my thanks to Messrs. E. M. Weston and J. M. Neill for their favourable reception of my paper.

SOME SUGGESTIONS ON IRRIGATION

By A. Baguley, B.Sc., F.I.C. (Member).

(Printed in Journal, March, 1920.)

REPLY TO DISCUSSION.

Mr. A. Baguley *(Member):* The contributors to the discussion on this subject have, in many cases, answered each other, and little remains except to thank them for letting me down so lightly, and respond to the invitation for enlargement on certain details.

The point that impresses me most in Mr. John Watson's interesting supplement is that 65% of the population of India is still dependent upon agriculture for the means of livelihood. What a population! What is better than agriculture to depend on?

In reply to Mr. C. J. Gray's question as to whether underground irrigation has been carried out on any large scale, I can only refer him to Mr. Ingham's contribution. As to this latter, it may be remarked that prime cost is determined by many considerations, and underground irrigation should not

be condemned for ever because one large scale trial proved unsatisfactory. Trees are not an essential or invariable condition of an irrigation scheme. Underground irrigation would be much the same with regard to "brak" as surface irrigation. Any method that provides for drainage cannot fail to be beneficial in removing "brak."

Dr. Caldecott's suggestive addition should properly receive an extended reply, and Mr. Stead has gone into some detail on the matter of oxygen absorption. I do not consider the beneficial effect of oxygen to be solely due to its oxidising ferrous compounds. It is certainly of great use in oxidising nitrogen. But the principal use of oxygen in soil is in the oxidation of organic matter, converting this ultimately into carbon dioxide, water, nitric acid, and sulphuric acid, and providing energy for countless hosts of living things, active in the production of plant food. Ferrous compounds form a small proportion only of the mass of the soil, but they are of great service in transferring oxygen from solution in water to combination with organic matter. They function in the soil, under soil conditions of temperature and moisture, much in the same way as copper or mercury compounds do in Kjeldahl's reaction, being oxidised and reduced repeatedly. In both cases the result is the combustion of the organic matter. In securing fertility, the oxygen of the air is of more importance than the nitrogen, being in greater demand and less supply.

In reply to Mr. Stead's question as to the caking of the surface, I have no figures. The caking I look upon as due not so much to the kind, still less to the quantity of dissolved salts, but chiefly to the proportion they bear to the water present.

THE IDENTIFICATION OF QUARTZ PARTICLES IN KONIMETER SAMPLES.

By Dr. A. W. Rogers, F.R.S. (Member).

(Printed in Journal, April, 1920.)

REPLY TO DISCUSSION.

Dr. A. W. Rogers, F.R.S. *(Member)*: Mr. Atkin's method of applying the liquid to a spot in a way that allows the spot to be in view during the operation is a very useful improvement. I have tried it and found it to work very satisfactorily.

Dr. Moir attributes more to the method than can be attained by it; it is not correct to assume its applicability to particles "too small to have a definite shape even under high magnification," *i.e.*, to irresolvable particles. The resolution attainable with the optical system used is the limit; above that limit both shape and transparency are determinable, but below it neither shape nor transparency is seen. It would be an advantage to use a pure liquid rather than a mixture, but the condition that the liquid must be a solvent of vaseline limits the choice. I am obtaining for experiment certain liquids suggested to me by Dr. Moir.

The approximate figure 1·58 quoted by me for the index of bromoform should have been 1·59; it is given by Wulfing and Rosenbusch as 1·588, by Johannsen as 1·589, and by van der Kolk as 1·590. The mixtures of bromoform and monobromobenzene which I used were tested on powdered quartz, mica and talc, and, one being obtained with an index intermediate between the highest of quartz and the middle and highest of talc and mica (those which come into play when basal flakes are examined), it was used for the konimeter samples. As stated in the paper, solution of the vaseline film was not found to lower the index of the mixture by too much; the figure 1·57 given in the table on p. 178 was a guess, and should have been preceded by "about"; it is of course the index of the mixture finally used, *i.e.*, after solution of vaseline.

As regards Mr. Thorne's question, it would be easy to find the index of an oil, using an ordinary drop on a total refractometer, but the index cannot be assumed to be the same after the oil has gone through a machine. Probably the oils used in mining machinery are solvents of vaseline, just as motor car oils are. In the examination of a dust spot immersed in liquid under a cover slip, each particle above the limit of resolution is seen and its shape in one plane observable, provided that the indices of particle and liquid differ by 0·002 or more; bubbles and drops are easily distinguished from solids under these conditions, but their distinction is difficult or impossible when the dust spot lies on the uncovered and uneven surface of vaseline.

INFORMAL DISCUSSION ON OVERTIME.

The President: As the hour is still early, it has been suggested that we might usefully fill in the remainder of the time with

an informal discussion. I think the question of overtime seems to be bulking largely in the minds of some people who direct and those who are supposed to follow. Mr. Pam has a good deal he could say on this very interesting subject.

The following took part in the very interesting and instructive discussion on overtime:—Messrs. E. Pam, H. A. White, G. Gibson, the President, J. R. Thurlow, J. W. Travers, H. Pirow, J. H. Johnson, and Mr. Pam replied to the discussion.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

New Method for the Volumetric Estimation of Nickel.—The process depends on the fact that when a nickel salt reacts with dimethylglyoxime, acid is liberated, which is estimated by titration with alkali in presence of phenolphthalein or methyl red. A standard $N/50$ solution is prepared by dissolving 4·6400 gm. of dimethylglyoxime in the requisite quantity of 97% alcohol (300 cc. to 400 cc.); 20 cc. of $N/1$ potassium hydroxide solution is added with constant shaking, the solution is diluted to 1000 cc. with CO_2-free distilled water and filtered after 24 hours from any slight precipitate of potassium carbonate (the alcohol used must be free from aldehyde and neutral in reaction). The alkali content of the solution is checked by titration with standard acid using phenolphthalein or methyl red as indicator. The nickel solution under examination is diluted to the required extent, exactly neutralised with $N/10$ or $N/50$ potassium hydroxide solution, 2 cc. to 5 cc. of the standard dimethylglyoxime solution is added, and, after vigorous agitation, the mixture is gently warmed, whereby the precipitate is caused to collect leaving a clear liquor; the standard solution is then gradually added with frequent agitation until the solution acquires a permanent pale pink coloration. In consequence of the bulky nature of the nickel precipitate the amount of the metal in the solution should not exceed 0·3 gm. The method is particularly advantageous in dealing with very small quantities of nickel, and titration can readily be effected with $N/100$ solutions if methyl red is used as indicator. The results are not affected by the presence of the alkali salts of strong acids.—I. Holluta, *Monatsh. Chem.*, 1919, *40*, 281-291 - *J. Soc. Chem. Ind.*, Dec. 31, 1919, p. 964a. (J. A. W.)

Estimation of Zirconium.—Zirconium can be quantitatively precipated as secondary zirconium phosphate in cold or tepid solutions containing 2% to 20% by weight of sulphuric acid, provided that a 10 to 100-fold excess of the precipitant, diammonium phosphate, is used. Hydrolsis, which occurs when the phosphate precipitate is washed with water, can be almost entirely avoided by the use of a cold 5%, ammonium nitrate solution for washing. Zirconium pyrophosphate, for which the factor (ZrO_2) is 0·4632, is obtained on ignition of secondary zirconium phosphate which has been washed with ammonium nitrate solution. No definite composition can be assigned to the compound resulting when secondary zirconium phosphate, which has been washed with water, is ignited. Zirconium can be quantitatively separated as phosphate in a 20% sulphuric acid solution from iron, aluminium, chromium, cerium, and thorium. The separation from titanium can also be effected provided that hydrogen peroxide is present.—G. E. F. Lundell and H. B. Knowles, *J. Am. Chem. Soc.*, 1919, *41*, 1801-1808.—*J. Soc. Chem. Ind.*, Jan. 15, 1920, p. 46a. (A. W.)

Molybdenum in Iron and Steel.—A specific and very sensitive test for molybdenum is given by xanthic acid. The test is best carried out with freshly prepared xanthate solution in the following manner: A solution of potassium hydroxide in absolute alcohol is shaken with excess of carbon bisulphide until no more of the latter is dissolved. To the solution so obtained 30% acetic acid is added until a slight yellow turbidity is formed, and the reagent is added drop by drop to the solution to be tested. If the latter has been prepared by dissolving the test material in strong acid, most of this should be neutralised before adding the reagent. If molybdenum is present an intense red colour immediately develops, which is quite stable in water and the intensity of which is proportional to the amount of molybdenum present. The sensitiveness of the reaction is such that 0·000005 grm. Mo in 0·0007% solution can be detected with certainty in presence of other elements. The colour is readily soluble in alcohol, amyl alcohol, ether, and chloroform, less readily in petroleum spirit and benzene. It is readily extracted from its reddish-violet ethereal solution by alkalis, and is precipitated from the alkaline solution by acids. The ethereal solution decomposes on standing with formation of molybdenum tungsten, titanium, or uranium; chromates give a dark coloration with xanthic acid, and should be reduced, if present, before the test is made. The reaction can be used for the colorimetric estimation of molybdenum, by comparison with a standard solution, but since ethereal solutions decompose too quickly, the ether should be mixed with 35% of petroleum spirit for the extraction and with 70% of petroleum spirit for the necessary dilution.—S. L. Malowan, *J. Soc. Chem. Ind.*, January 15, 1920, p. 27a. (A. W.)

Preparation of a Hydrochloric Acid Solution of Cuprous Chloride.—Comparative tests showed that the efficiency of cuprous chloride solution for the absorption of carbon monoxide is not deleteriously affected by the presence of relatively large amounts of stannous and stannic chlorides. A satisfactory reagent is obtained by reducing cupric chloride, and if a small excess of stannous chloride is used the solution may be exposed to air during transference from one vessel to another without the cuprous chloride becoming oxidised. Further, the solution may be renewed, after saturation with carbon monoxide, by heating to 60°—

70° C. to drive off the gas, a few drops of concentrated stannous chloride solution being added to correct any oxidation which might occur.—F. C. Krauskopf and L. H. Purdy, *J. Soc. Chem. Ind.*, 30th April, 1920, *12*, p. 316A. (J. A. W.)

Recovery of Ammonium Molybdate.—"The mixed filtrates, precipitates, etc., are neutralised partially with ammonia, the molybdic acid is precipitated at 80° C. with sodium phosphate, and the yellow precipitate is collected, washed, and dried. Four kilos. of the dry yellow powder is dissolved in 6 litres of water and 4 litres of ammonia (sp. gr. 0·91), and a solution of 500 gm. of crystallised magnesium nitrate is added; the total volume should be not less than 11 litres. The ammonium magnesium phosphate is removed by filtration and the filtrate is concentrated, ammonia being added from time to time to prevent dissociation and separation of molybdic acid. Crystals of ammonium molybdate are removed occasionally until the solution has a volume of about 750 cc. On cooling, magnesium nitrate separates with the ammonium molybdate, but may be removed by washing the crystals of the latter with a small quantity of water. The ammonium molybdate thus obtained is recrystallised, first from very dilute ammonia solution and then from water."—H. Neubauer and E. Wolferts, *Z. anal. Chem.*, 1919. *58*, 445-448.—*J. Soc. Chem. Ind.*, 30th April, 1920, p. 317A. (A. W.)

Determination of Oxygen by the Copper-Ammonia-Ammonium Chloride Reagent.—"Hempel's method for the absorption of oxygen by means of metallic copper spirals covered with a solution containing equal parts of saturated ammonium carbonate solution and ammonia of sp. gr. 0·93, was the basis for a series of experiments in which varying strengths of ammonia and ammonium salts other than the carbonate were used The best results were obtained with a mixture of one part of concentrated ammonia (sp. gr. 0·9) and one of water saturated with ammonium chloride, the specific absorption of this mixture being 55-60 vols. This reagent is cleaner and has a longer life than pyrogallate; unlike phosphorus, it is unaffected by catalysts, and it is readily prepared and is active at almost any temperature. On the other hand, it cannot be used for mixtures containing carbon monoxide or acetylene, and when fresh it is liable to leave measurable amounts of ammonia in the gas.—W. L. Badger, *J. Ind. Chem.*, 1920, *12*, 161-164.—*J. Soc. Chem. Ind.*, 30th April, 1920, p. 317a. (J. A. W.)

Peat.—The uses of peat are numerous and varied In the countries of northern Europe it is used for fuel and as the basis for many manufacturing industries. Gas, charcoal, coke, and a number of valuable products are produced from it. Owing to the scarcity of raw materials in Europe, peat and peat moss are also employed as substitutes for absorbent cotton in the preparation of surgical dressings, for wool and for cotton and woollen cloth.

In the United States peat is utilised chiefly as fertilizer and fertilizer filler, as stable litter, and as an absorbent for the uncrystallized residues of beet and cane sugar refineries in the manufacture of stock feed.

Peat has long been used in fertilizing the soil, having been either employed as a direct fertilizer or used as a filler for commercial fertilizer. Analyses of the peats of the United States show an average nitrogen content of about 2 per cent., a proportion somewhat higher than that found in some commercial fertilizers. The value of peat in soil fertilization is found in its nitrogen content and in the beneficial mechanical effect it produces upon certain lands. Black, thoroughly decomposed peats are most satisfactory for fertilizer, as such peats are generally heavier and more compact and contain more nitrogen and less fibrous material than the brown types.—*U.S. Geol. Survey Bulletin*, 445, *Journal Franklin Institute*, June, 1920. 189.6.780 (J.A.W).

METALLURGY

Treatment of Steel: Use of Salt in Heat Treatment of Steel.—"Considerable advance has been made of recent years in our knowledge of the constituent elements of steel and its requisite treatment in order to obtain the best results. Recent research has emphasised the importance of accuracy and precision in this connection. Slight errors in treatment may render potentially good steel useless, and the best results are only obtainable by the introduction of better methods for the observation and regulation of temperature than have generally been used in the past. Some useful information is concisely presented in a pamphlet recently issued by Messrs. John Wright and Company, on the 'Use of Salts in the Heat-treatment of Steel.' This firm has been for nearly twenty years the pioneers in the use of fused salts and temperature-measuring instruments in connection with the hardening of tool steel, and in more recent years its researches have extended more generally to the heat-treatment of steel and other metals or alloys.

The objections to atmospheric furnaces are pointed out such as the difficulty of obtaining uniformity in the heat-treatment of articles, and the injury to the steel under treatment in many cases where long soaking is resorted to for securing final uniformity.

The advantages of using various liquids composed of fused salts or mixtures of salts for the heat-treatment and the hardening and tempering of steel are as follows:—The temperature of a liquid may be regulated very accurately and cannot vary in a few moments; any article immersed for a sufficient length of time must heat throughout to the same temperature as the liquid, and the sharpest corner cannot be overheated so long as the liquid itself is kept at the desired temperature.

Various kinds of melts have been evolved for various processes and these are briefly described in the pamphlet. They comprise molten lead (which, however, has many objections, and numerous difficulties are encountered in its use); barium chloride for high-speed steel; 'pyromelt' for heating carbon steel or carbonised work; 'Fuesalt' for quenching, high-speed steel, for tempering, and for heat-treatment; 'Tempermelt,' for tempering and for heat-treatment; and patent 'Quenchoid,' for quenching carbon steel, for tempering, and for heat-treatment.

Furnaces are provided for various salts. 'Pyromelt' is used in a salt bath such as is shown in the illustration herewith, or in a lead bath. The latter is similar to the salt bath, except that it is not provided with the upper structure, including the tray to carry the work. 'Tempermelt,' 'Fuesalt,' and 'Quenchoid' are also used like 'Pyromelt' in a salt bath or a lead bath, but usually they are worked at a comparatively low temperature only, in which case they are used in a tempering bath or in an open bath. The open bath is similar to the tempering bath, except that it is not provided with the upper structure for carrying a strainer.

'Pyromelt' is used for heating articles of carbon steel or for re-heating carbonised work, preparatory to quenching in water. It fuses at about 680° C. (1,256° F.). It circulates freely in the pot, is non-poisonous, and has no deleterious action on the steel. The waste by volatilisation is so slight as to be negligible. It is so light that the trouble, inherent in the case of lead, of articles floating on the surface does not arise.

'Fuesalt' fuses at about 210° C. (410° F.). The tools are raised to the ncessary high temperature in a Wright-Brayshaw Patent Twin-Chambered Furnace, after which they are quenched out in 'Fuesalt,' which is very much hotter than boiling water, but not at a red heat. As soon as the tools reach the same temperature as the 'Fuesalt,' they are taken out and allowed to cool in the air. The 'Fuesalt' is swifter in its action than oil, and cools the tools more rapidly, but when it has done its work the temperature is still so high that the strains are released, if indeed they have ever been set up, so that cracking and distortion are avoided."—*The Engineering Review*, 15th January, 1919, 206 and 207. (J. J. R. S.)

A Non-Corrosive Metal.—Tantiron.—Tantiron is the name given to a non-corrosive alloy manufactured by the Lennox Foundry Company, Ltd. It is a hard close grained, silvery white alloy, melting at about 1,200° C., which does not rust or oxidise, nor is it attacked by ordinary corrosives to any practical extent. It can be treated exactly like cast iron, and castings varying from a few ounces to many tons in weight can be made with equal ease.

It differs from all other non corrosive alloys, inasmuch as its resistance to corrosion is general and not specific. Muntz metal, for instance, is not atacked by sea water, and nickel alloys do not rust, but all such metals are easily attacked by acids. Again, truly non-corrosive bodies such as the carbides are quite unfitted for the manufacture of plant, as they cannot be cast in the foundry, nor be machined.

Although in the earlier stages, Tantiron, was found difficult to machine, and all finished surfaces had to be ground from the rough casting, it can now be drilled, turned, planed, or screwed, and still retains its non-corrosive properties, thereby proving of great value in the manufacture of centrifugal pumps, spray-jets, ejectors and valves of all types.

As regards physical properties, it has been found, as a result of many experiments, carefully conducted, to possess practically twice the thermal conductivity of lead and four to five that of stoneware or quartz—an immense gain in either heating or cooling fluids. Its hardness is some fifteen times that of Regulus metal, giving cocks, valves, ejectors or similar plant a proportionately longer life, whilst its density and hardness enable the manufacturer to adopt lighter and more practical designs than is possible with lead antimony alloys.

For the guidance of manufacturers who wish to design their own plant, the following physical constants, contrasted for convenience with cast iron, may be of interest :—

	Cast Iron.	Tantiron.
Density	7·3	6·8
Tensile strength, tons per sq. in.	9-10	6-7
Transverse strength of 12″ x 1″ bar	2,500 lbs.	1,600 lbs.
Crushing—1″ cubes ...	40 tons.	34 tons.
Melting point	1,150° C.	1,200° C.
Hardness	1	1·6
Thermal conductivity...	10	8
Electrical resistance ...	8	10
Corrosion resistance ...	1	1,000
Contraction allowance in casting	$\frac{1}{8}$″ per sq. ft.	$\frac{1}{16}$″ per sq. ft.

Tantiron has been used in the manufacture of nitric acid and sulphuric acid plants, acid pumps, cocks, valves, pipes, fittings, and various vessels required to withstand exposure to corrosive materials."—*The Engineering Review*, 15th February, 1919, p. 232. (J. J. R. S.)

New Method of Adding Water to Conical Mills.—*Larger Capacity and Reduction of Oversize Accommplished by the Use of a Water Spray in the Discharge Cone—Utility of Water Rheostat.*—It is the present general practice in the operation of ball mills to add all of the water to the feed end of the mill. Experimentation and tests made by C. W. Dowsett, of the Bluestone Mining & Smelting Co., Yerington, Nev., have proved that, in his case, better results are secured in the Hardinge conical mill by adding a part of the water, or some additional water, just inside the discharge end of the mill. The assumption is that while the ore is coarse little or no water is required, excess water merely acting to break the fall of the balls and wash away the finer ore particles. As the ore passes to the discharge end of the cone, however, the surface area of the ore particles is considerably increased, so that the pulp becomes very thick. This prevents proper classification and results in large pieces of ore, $\frac{1}{2}$ to $\frac{3}{4}$ inches in diameter, discharging with the finer material. The dilution of the water spray allows the proper classifying action in the discharge cone to take place.

Mr. Dowsett has inserted a $1\frac{1}{4}$in. water pipe in the discharge trunnion of his mill, fitted with a $\frac{3}{4}$-in. nozzle so directed that a spray impinges on the rising side of the pulp about 18 in. to 2 ft. inside the mill. He has found that by shutting off this water spray for five minutes the amount of oversize is greatly increased.

While at the Dome, Mr. Dowsett also experimented with a water rheostat in connection with the motor used to drive the 8-ft. by 30-in. Hardinge mill at that plant, coming to the conclusion that a variable speed motor would possess certain advantages for a ball-mill drive. In these tests he found that with a slight variation in the hardness or size of the feed, a moderate increase or decrease in the speed of the mill, obtained by raising or lowering the plates of the water rheostat, was

necessary to keep the capacity of the mill at a maximum. Sometimes a variation of $\frac{1}{2}$ to $\frac{1}{4}$ of a revolution per minute made a marked difference in the capacity. In view of this fact, he believes that the motor should be sufficiently oversize to prevent line surging, as this surging will cause considerable fluctuations in the speed of the mill.

Another aid to greater capacity which Mr. Dowsett claims is the use of a restricted throat in the feeder, with large diameter trunnions. In this way he gets more of the action of a Frenier sand pump and an actual hydrostatic head to force the feed into the mill.

Whether or not better results can be secured in ordinary mill practice by the above suggestions can be easily tested. An ammeter may be placed in the power circuit, and the water may also be metered when the spray in the discharge is tried, in order to determine the best conditions of operation. Under certain conditions, a thickening of the coarse ore pulp will result in an increase of both the power required and the grinding efficiency. If the pulp becomes too thick, more power is required but less grinding will be done, so that it devolves upon the operator to secure a critical medium.—C. W. Dowsett, *Eng. and Min. Journal,* Aug. 2, 1909, p. 185. (H. A. W.)

MINING.

Applications of Ferro-Concrete in Mines.—An example of the utilisation of ferro-concrete is in the construction of air-tight pithead chambers, an early application of which was made in 1910 at the Penalta Colliery of the Powell-Duffryn Steam Coal Company, Limited. Such chambers may be made far more air-tight in ferro-concrete than when built of steel, which then resist with difficulty the severe vibration communicated from the pithead frame. The Penalta chamber is 130 ft. long, with a maximum width of 30 ft.

In the same line of utilisation may be mentioned the construction of fan chambers. An example is the fan-house and chamber built at the Holytown Colliery of Messrs. Nimmo & Company, Limited, from the designs of Messrs. Home-Morton, Ker, and Gibson. The diameter of the air-shaft was 11 ft. in this case.

Another interesting application in connection with ventilation is that of the engine-room floor at the St. Hilda Colliery of the Harton Coal Company, Limited, which carries a ventilating fan weighing nearly 10 tons, and the two motors and their foundations weighing 72 tons. Special pockets are built in the floor, so as to form air intakes.

Another important use to which ferro-concrete is put in surface work for collieries is the construction of coal hoppers. One of the earliest applications of such construction in this country was at the Clifton Colliery of the Allerdale Coal Company. The height of the bunkers is 84 ft., to which must be added that of the light steel roof. The hoppers are 41½ ft. long by 21½ ft. wide, and hold 500 tons of coal. The aerial ropeways exert a pull of 10 tons, and great care is taken in consequence to insure special rigidity in the long columns which support the main body of the hoppers. Many bunkers of a similar nature and of greater magnitude have been built since that early example; for instance, the bunkers at Bargoed Colliery for holding 1,000 tons of coal, which rise to a height of 110 ft. Also bunkers at Port Talbot, with a capacity of 21,000 tons.

Another type of bunker not so frequently met with is that built at the Britannia Colliery, Pengam, of the Powell-Duffryn Steam Coal Company, Limited. Rising to a height of 95 ft., this circular bunker has a diameter of 32 ft., the storage compartment being 66 ft. high with a capacity of 1,500 tons. Circular bunkers of this kind provide a very cheap means of storing coal.

Among other surface works for which ferro-concrete is often found useful may be mentioned—chimney stacks. One built for the Nuneaton Colliery, Limited, at Nuneaton, has a height of 103 ft., the diameter at the top being 7 ft. At a time when bricks are practically unobtainable ferro-concrete chimney shafts are very advantageous. They are considerably lighter than brick shafts, and reduce greatly the strain on the foundations, which is an important consideration when subsidences may be anticipated. Their monolithic character also provides additional security in case of unequal settlement.

The same desire to insure security in case of subsidences due to the pit workings has led in several cases to the construction in ferro-concrete of the foundations required for the machinery at the pitmouth. One of the earliest applications in this country was the foundation raft for two Ilgner flywheel motor-generator sets at the Pengam Colliery. The general dimensions of the raft were 102 ft. in length by 20 ft. in width, with a depth of 17 ft. The total weight of the machinery exceeds 200 tons, each of the two flywheels weighing 30 tons. They run normally at 500 r.p.m., but can be slowed down to run at 425 revolutions if necessary. The continual speeding-up and slowing-down causes severe stresses in the foundations, but owing to the scientifically arranged network of steel rods throughout the ferro-concrete work, no ill-effects accrue.

Ferro-concrete may be put to many more uses on surface work, as, for instance, in the building of bridges. An example of cheap and efficient bridging is that carried out for the Rhymney Iron Co., Ltd., at hymney. It is designed for mineral-line traffic, and has a span of 34 ft. Another important use to which ferro-concrete has been put at several collieries is the construction of water-tanks or reservoirs. It is a most suitable material for that purpose, and, both on account of its low prime cost and of the total absence of cost in upkeep, it compares very favourably with steel tanks. A reservoir for holding 80,000 gallons of water was built many years ago at Bargoed Colliery.

The construction of water-tanks for collieries is not restricted to surface work, and one of the earliest applications of ferro-concrete to underground work was in the making of three tanks, in 1906, some 1,600 ft. below ground at the Boldon Colliery of the Harton Coal Company, Limited. They each have a capacity of 5,500 gallons. The
each have a capacity of 5,500 gallons. The
galleries were 7 ft high and 11 ft. wide, whilst the tanks were 6 ft. high and 8½ ft. wide overall,

and were laid against one of the walls. The workmen were therefore very much cramped for want of space during the course of construction; but, as all the steel reinforcement was composed of small rods, mostly ⅜ in. in diameter, there was no difficulty in bringing them in to the galleries and in placing them in position. The tanks having given full satisfaction, the company ordered in 1910 a larger tank, with a capacity of 18,000 gallons, for their Harton Colliery. In this case the tank occupied the end of an old gallery; it was 10 ft. high, and occupied the full width of 17 ft., three sides of the tank being in touch with the front face and walls of the gallery. As the ferro-concrete walls are only from 4 to 6 in. thick, whereas the walls of a brickwork tank sufficiently strong to hold 9 or 10 ft. of water would have had to be at least 18 in. thick, the tank holds approximately 25% more water. In narrower galleries the advantage of ferro-concrete in that respect is still more marked.

There are many other examples of the application of ferro-concrete to underground workings. In 1912 an outbreak of fire at the Tunnel Pit of the Haunchwood Collieries, Limited, of Nuneaton, led to the adoption of ferro-concrete for the insets 1,000 ft. below ground in order to avoid any danger from fire, which would have accompanied the adoption of timber, and to avoid the much greater thickness of ordinary concrete, in which arched lattice girders were to be embedded, which was contemplated as an alternative. Instead of 4½ ft., it was found possible with ferro-concrete to reduce the thickness to 18 in. at the crown and 3 ft. 9 in. at the haunches. The cost and trouble of bringing building materials to such a place are great, and any reduction in the quantities required is consequently of importance.

Arching of that description is, of course, not restricted to insets, and may be applied to the galleries as well. Steel joists bent to the required shape are often embedded in concrete every few feet. It is undoubtedly a move in the right direction, but it is rather an expensive method, whilst the handling of steel joists in such lengths as it would be theoretically advisable to use is not always easy in mines. The greatest drawback of isolated joists, however, is that every joist acts independently and has to take uneven and concentrated loading without any assistance from the others. Owing to the lack of longitudinal reinforcement between them, the concrete would fail in shear before transferring much of the load from one joist to those adjacent. The advent of ferro-concrete arching, in which the steel joists are replaced by numerous closely-spaced bars of comparatively small diameter, thoroughly braced by longitudinal bars, was therefore a step in the right direction, the whole arch being without joints and, in fact, resembling a huge casting.

In yet another respect ferro-concrete linings present an advantage, namely, their smoothness and the possibility of dispensing with any projections renders the flow of the ventilating current much easier.

Ferro-concrete pit-props have been used, in lengths varying from 3 to 10 ft., for some time both in the Midland and in the South Wales collieries. Various collieries have been experimenting, using often as reinforcement lengths of old ropes or guide-rods. Often the results have been indifferent, if not unsatisfactory, owing generally to the faulty method of reinforcement, to the poor nature of the aggregate used, and the faulty proportioning of the aggregate (sand and cement). Simple as it may seem at first, the problem of ferro-concrete pit props is a difficult one, just like that of the ferro-concrete railway sleeper, with which it has many analogies. The tests carried out so far show that ferro-concrete props may easily carry loads greater than those usually allowed for timber props. A satisfactory feature also is that, when they are properly designed and constructed, they generally fail at the end, instead of failing under pressure in the middle, as is the case with timber. They can therefore be used again after the damaged end has been dressed. Their great drawback is that they are heavier, they do not stand hammering so well as timber and can take a much longer time to saw than timber. Experiments are being carried out at present with a view to using special aggregate in order to lighten the props, and also to allow of a few inches being cut off more easily, if necessary, at either end.

Ferro-concrete has been used for the construction of efficient stoppings in the cross-cuts between main air passage-ways, the advantage found being that they may be built at a reasonable cost. They entail no maintenance cost, are incombustible, unaffected by water, and have a high bearing strength to assist in supporting the roof. Concrete-block stoppings have been used in several cases. They were already an improvement on the old style of stoppings but were occasionally destroyed by a near-by, windy, or blewn-out shot, or a general mine explosion. Ferro-concrete, owing to its reinforcement, is able to stand uninjured in most cases of explosion, and is therefore to be preferred.

Ferro-concrete is used also in shaft-sinking. An example which has aroused a great deal of interest is that of the Coventry Colliery, Keresley, carried out in 1914 under the direction of Mr. Albert François. The minimum thickness of the ferro-concrete walling which has been employed is 18 in., and the pressure of water closed off corresponds approximately to the static head from the surface.

Concrete blocks for shaft linings have been used in a few instances. Ferro-concrete has been suggested as an improvement, as it would permit of reducing considerably the thickness of the casing, and consequently the diameter of the excavation, by 2 or 3 ft., or even more, which is an important consideration. This application, however, has not, as yet, stood the test of time."—T. J. Gueritte.—*Iron and Coal Trades Review*, Dec. 26, 1919, p. 835. (J. A. W.)

Wire Ropes in American Mines.—"In the course of its investigations on safety in mining, the Fuels and Mechanical Equipment Division of the U.S. Bureau of Mines has collected much information bearing on the use of wire ropes, and has now published a Technical Paper (No. 237) by Messrs. R. H. Kudlich and O. P. Hood, outlining approved practice in the United States and

the more important precautions recommended to ensure safety. The following is an abstract of the paper.

At the outset the advice is given never to exceed the working load of the rope as given in the manufacturer's table. The rope must have a factor of safety to allow for wear, corrosion, and severe strains due to starting, etc. The following values for the factor of safety are recommended by the Bureau for hoisting ropes for various depths of shafts :—For a length of rope of 500 ft. or less a minimum factor of safety of eight for the new rope, and a minimum of 6·4, when the rope must be discarded. The corresponding values for a rope 500 to 1,000 ft. long are 7 and 5·8 respectively; for a rope 1,000 to 2,000 ft. long 6 and 5; for one 2,000 to 3,000 ft. long 5 and 4·3; and for one of 3,000 ft. and over 4 when new, and 3·6 when old.

The material and construction of the rope should be adapted to the service in which it is to be used. Use soft steel rope in shallow shafts where there is strongly acid water and the drums or sheaves are small. Use hard-drawn steel or plough-steel rope in deep shafts, on slopes, or on rope-haulage ways. Ropes made of the softer grades of steel are more flexible and less affected by corrosion, whereas ropes made of steel of high tensile strength are not so heavy for a given strength and resist abrasion better. Where flexibility is required, a rope of a large number of small wires may be used if it is not subject to excessive external wear, whereas a rope made of a smaller number of larger wires must be used where the rope is subjected to severe external wear. The smaller the wires the greater the strength and flexibility of the rope. In vertical shafts in America the rope generally used is made of six strands of nineteen wires each, laid around a hemp core. In slopes and on haulage ways where the rope is subjected to excessive wear by rubbing against the sides, floor, and roof, the rope generally used is composed of six strands of seven wires each, laid around a hemp core.

Lang-lay rope should be used except where the tendency of the rope to untwist is harmful and cannot be resisted. In such places regular-lay ropes or special non-spinning ropes should be used. Lang-lay rope should be used especially where external wear is severe, if it can be prevented from untwisting. Regular-lay rope does not tend to untwist when loaded, but only a small portion of each wire in a strand is subject to external wear against sheaves, drums, and to internal wear against the wires of the other strands, while Lang-lay rope tends to untwist under load, but a considerable length of each wire comes in contact with the sheaves or drum, or with the wires of another strand, and thus wear on the outside of the rope is distributed and 'nicking' of the inside wires is greatly reduced.

New ropes should be long enough to permit cutting off the end and resocketing six times or more. At least two laps of rope must be on the drum when the cage, car, or skip is at the bottom of the hoist after the last cutting has been made. Ropes used on shafts or slopes for handling men must be in one piece from end to end, and not spliced. Ropes used on slopes where men are not handled and on haulage ways may be spliced, but the splice must always be made sufficiently long to allow the strands to lock well into one another.

In balanced hoisting, the length of the two ropes must be so adjusted that when one cage or skip is at the top landing the other will just rest on the bottom. Any slack rope will cause the cage to start with a jerk, especially if the engine is started rapidly, causing severe stress in the rope.

Sheaves and drums must be at least as large as the minimum size recommended by the rope maker, and should be as large as conditions permit. They must be well balanced, be as light as is compatible with strength—in order to cut down inertia in starting and stopping—and should have well-oiled bushed bearings. In good practice, the diameter of sheaves should be 66 to 100 times the diameter of the rope. Ropes made of large wires and steel of high tensile strength require larger sheaves than the minimum specified for that size of rope. Sheaves with smooth, well-chilled iron throats or with rubber-lined throats will last longer and wear the rope less than those with rough, soft-iron throats.

The hoisting drum must be so set that the maximum fleet angle will not cause the rope to crush against or climb on the rope already on the drum or rub against the sides of the groove of the sheave or the grooves of a drum. The maximum fleet angle will vary with the size of rope, and with the size, and shape, and length of the drum. An angle of $1\frac{1}{2}$ degrees on either side of a plane passing through the centre (hoisting) line of the shaft or the slope and the sheave, is permissible for ordinary proportions of rope and drum. The fleet angle for extra small or long drums should be calculated for each drum.

The rollers or idler sheaves should be light, true, and supported on easy-running bearings to make them start and stop easily. The rope must be prevented from rubbing against the side walls, roof, or bottom at curves, by a series of small rollers or sheaves so placed as to cause only a small deflection angle at each roller. The diameter of such turn sheaves or rollers should be at least eight-tenths of the deflection angle times the diameter of the rope.

Ropes must be stored in a dry place; they must not be kept in a place so hot as to destroy the hemp core.

If one broken wire is found in the rope at the fastening, the fastening should be cut off and renewed. Even if no broken wires are found, the rope must be cut off and the fastening renewed periodically, as this is the weakest part of the rope and most liable to suffer from bending and vibrating stresses. The length of time between renewing and fastening should vary with the life of the rope. The following rule gives approximately the period recommended in the Bureau's 'Rules and Regulations for Metal Mines' —Time interval permissible between resocketings for ropes is equal to the expected term of service divided by six; but it should in no case exceed four months. A piece of rope equal in length to half the circumference of the sheave should be cut off when a fastening is renewed, so as to bring a new part of the rope in contact with the sheave where the wear is most severe. After three years in service, even if idle, ropes may not be used unless tested for ultimate tensile strength. Unlay the piece of rope cut off and examine the inside wires for corrosion and wear. If they are broken, badly worn, or corroded, cut off another piece and

examine it. If a considerable length of rope is in bad condition, the rope must be discarded.

At some mines it has proved advisable to turn the rope end for end after it has been in service some time, thus equalising the wear on the two ends. If the same size rope is used in two shafts, in one of which men and material are hoisted, and in the other material only, it is well to use a new rope first in the former shaft until it shows signs of wear and then put it in the latter and wear it out there. Likewise a rope can be used first on a shaft and then worn out on a slope or haulage way.

A hoisting rope should be considered as a piece of machinery, having many wearing surfaces that must be thoroughly lubricated. The lubricant should consist of oils and greases that will penetrate between the wires and the strands, and should not harden on the outside. A lubricant that hardens is cracked while bending over the sheaves and drums, so that moisture can penetrate to the centre and cause internal corrosion. Tar should never be used; it forms a hard shield on the outside of the rope and does not penetrate and lubricate the inner parts. If possible, the rope should be lubricated when dry, so as to give the lubricant a better opportunity to penetrate the core and to adhere to the wires. The lubricant must be applied often enough to keep the wires well covered and to keep the hemp core from drying out. All the accumulated dirt and gummed lubricant should be cleaned from the valleys between the strands of the rope so that the fresh lubricant can penetrate.

Hoisting ropes should be inspected at least once a day, and their condition noted and recorded by a competent man, who must be held responsible for the condition of the ropes. Special attention should be paid to the rope just above the socket; at the clamps and safety clamps, if these are used; where the rope rests on the sheave, and where it leaves the drum at each end of the hoist.

No standard rules for discarding ropes have been made; they vary with different conditions and in different localities. Various rules for discarding ropes are based on (1) the stretch of the rope; (2) the number of broken wires in a given length of rope or of the entire rope; (3) the amount of wear of the wires at the crown of the strands; (4) the length of time the rope has been in service; (5) the number of trips; (6) the tonnage; or (7) the ton-miles hoisted by the rope.

In the absence of more definite rules for discarding ropes, according to American practice, the following, quoted from 'Rules and Regulations for Metal Mines,' are suggested:—Safety factors must never fall below 4·5. Ropes of standard construction shall be discarded (1) when there are six broken wires in one rope lay; (2) when wires on crown are worn to 65% of their original diameter; (3) when there are more than three broken wires reduced by wear more than 30% in cross section; and (4) when marked corrosion appears. The suggestion as to the factor of safety, however, is in contradiction with the Bureau's own recommendation for ropes exceeding 2,000 ft. in length."—R. H. Kudlich and O. P. Hood.—*Iron and Coal Trades Review*, March 5, 1920, p. 325. (J. A. W.)

Abstract of Patent Applications.

540.19. Hermoye & Glorian. Improvements in or relating to reinforced concrete construction. 11.7.19.

This application refers to a method of reinforced concrete structures consisting of blocks built together with reinforcing rods. The individual blocks consist of hollow pieces, the hollow being elliptical in cross sections.

734 & 735.19. M. Mathy. Improvements in or connected with apparatus for heating by combustion without flame, and a new and improved burner. 11.9.19.

Patent application No. 734.19 is for a heating apparatus with flameless combustion of a gaseous mixture in the heart of a mass of fragments of porous refractory material, a means for regulating the temperature of the various parts to be heated, characterised by the fact that the size of the above-mentioned fragments at each part to be heated is less according as the temperature to be attained is higher. Other claims refer to the constructional forms of the furnace.

Patent application No. 735.19 refers to a burner for flameless combustion, comprising a chamber filled with porous refractory material into which the gas and air are introduced separately through adjacent openings, situated on the side opposite to the opening for the discharge of the products of combustion.

792.19. Ateliers Leonard Rocour Societe Anonyme of Ans-les-Liege. Improvements in pneumatic hammers for rivetting, chipping, cutting, and the like. 27.9.19.

This application refers to a pneumatic hammer of the type referred to comprising a hollow distributor having a cylindrical enlargement, characterised by the fact that the wall of the said enlargement remains solid, and that the escape of the air compressed at the back of the cylinder during the rearward stroke of the striker, is effected through distinct openings arranged in the body of the cylinder and uncovered by the edge of the hollow distributor, when the latter is in its back position, substantially as described.

895.19. Merz & McLellan. Improvements in the use of solid fuel for large scale power production. 7.11.19.

This application relates to improvements in the use of fuel for power production on a large scale. The chief feature of the application is the combination of a low-temperature distilling plant with the steam-raising and/or gas producing plant for the purpose of generating power.

It consists of a vertical retort automatically fed and discharged, the coke being immediately delivered on to a travelling grate of a boiler adjoining the retort, and the steam from the boiler being used to operate the turbine or engine. For distilling the coal, steam is taken from the turbine casing after partial expansion, superheated in the boiler.

The exhaust steam and circulating water are used for heating or cooling the gas given off from the retort as required, and there is the usual apparatus for cleaning and stripping the gas of its products, which is then available for power purposes.

913.19. Isaacs, Robertson & Moss. Improvements in pneumatic liquid elevators. 7.11.19.

The claims are two in number, and are as follows:—

1. A liquid elevating device consisting of one or more chambers, each fitted with an inlet opening having an inwardly opening valve, and a discharge pipe extending from near the bottom of the chamber and fitted with an outwardly opening valve, and means for alternately exhausting and supplying pressure air to the upper part of the chamber, said means in the case of a doubled chamber device, feeding and exhausting the chambers alternately with one another.

2. A liquid elevating device substantially as described with reference to the accompanying drawings.

1077.19. Gordon & Simpson (Vancouver). Improvements in rock drills. 22.12.19.

The application relates to rock drills, and more particularly relates to miner's machine drills employed in mines and harbour work where extra long drill rods are required.

The application is really for a special form of detachable bit, two such bits of semi-circular cross section with semi-circular cutting edges being disposed back to back. Specially shaped horns on the upper ends of these "bits" engage with reciprocally shaped recesses in the head piece, where they are secured by the clamping action of two bolts and nuts with locking pins.

That the arrangement is complicated is proved by the fact that the drawings accompanying the specification consist of 10 figures to elucidate which 31 reference characters are used.

382.20. Standard Oil Company of New York. Methods of and means for selecting grades of lubricants for internal combustion engines. 19.4.20.

This application has reference to a mechanical device whereby suitable grades of lubricants can be selected when assuming different factors with regard to automobile engines and conditions of service. The apparatus is in the nature of a circular slide rule whereby the different assumed factors are automatically added together on a suitable scale to give the desired result on the grade of oil required.

510.20. The P. & M. Company, Chicago. Improvements in rail anchors. 27.5.20.

This application relates to devices for preventing the longitudinal creep of railway rails, and consists of a steel clip of round or polygonal section which is fixed to the base of the rail by means of a special wedge, immediately in contact with the side of a sleeper, the combination being driven into position with a sledge hammer.

A resilient gripping action is produced from the shape of the clip and the method of securing it, and the clip being initially in contact with the side of a sleeper tends to prevent longitudinal "creep" in that direction.

574.20. J. Miller. Improvements in and relating to filter presses and the like. 14.6.20.

This application relates to improvements in apparatus for the closing and opening of filter presses, and consists of a combination of a screw head in which is incorporated pivoted counterweighted operating levers and a hydraulic head, etc.

575.20. Oscar Frederick Egeberg. Locking device for rail-spikes, woodscrews and the like. 14.6.20.

The application relates to the kind of railway spikes which are locked in position in the sleeper by means of a nail fitting into a groove in one side of the rail spike, said groove being so formed that it acts to bend the nail with its point sidewards into the wood when the nail is hammered down in the groove.

According to the present application the groove is so fashioned that, if the spike has a square or rectangular section the nail is bent in a plane parallel to the side which contains the groove, and if the spike is of the coach-screw type with a cylindrical body the nail is bent in a plane substantially tangential to the cylindrical surface.

577.20. Kenneth Gauldie, Glasgow. Improvements in apparatus for measuring forces and the like. 14.6.20.

This application relates to apparatus for measuring or recording forces applicable either as an independent apparatus or as a component part of a complex machine, such as, for example, a weighing machine, or a testing machine or a thrust bearing.

The apparatus appears to be an improvement on the ordinary type of hydrostatic weight indicating apparatus in which increased accuracy is gained by the elimination of cup leathers and such like packings, the friction of which is said to impair the accuracy of the indications.

In the design described the liquid operating the pressure gauge is contained in a suitable duct or ducts, generally annular, formed in the interior of a resilient body, such, for instance, as a bolster, cushion, or distance piece of india rubber or similar material, the latter being contained and laterally supported in a suitable metal cylinder.

Indications are on a pressure gauge suitably calibrated to read weight directly.

Changes of Address.

Adams, A. E., *l/o* Johannesburg: "Dunedin," Silwood Road, Rondebosch, Capetown.

Brise, H. R. Ruggles, *l/o* Finchingfield, Essex; Rosehaugh Co., Dar-es-Salaam, Tanganyika.

Dures, R., *l/o* Sable Antelope: Orphan's Luck (Asbestos) Mine, Shabani, S. Rhodesia.

Graham, W. Hastie, *l/o* Likasi Mine, Katanga: Abontiakoon Mine, Tarquah, Secondee, West Coast Africa.

Horsfield, J. E., *l/o* Planet Mine, Arcturus; P.O. Box 41, Livingstone, N. Rhodesia.

Mills, E. W., *l/o* Yokohama, Japan; 24 East Teung Pu Hutung, Pekin, China.

Pyles, J. F., *l/o* Rose Deep, Ltd.: Village Deep, Ltd., P.O. Box 1064, Johannesburg.

Wraith, C. O., *l/o* Johannesburg; P.O. Kaapsche Hoop, E. Transvaal.

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AT
Ordinary General Meeting, 20th October, 1920.

The Ordinary General Meeting of the Society was held in the University College, Johannesburg, on Saturday, 20th November, 1920, Mr. J. Chilton (President) in the Chair. There were also present:—

18 Members: Messrs. F. W. Watson, H. R. Adam, C. J. Gray, J. Hayward Johnson, Dr. A. J. Orenstein, J. J. R. Smythe, John Watson, E. M. Weston, J. A. Woodburn, Andrew F. Crosse (Members of Council), A. King, J. M. Neill, J. D. O'Hara, H. Pirow, S. H. Steels, J. A. Taylor, M. J. Thorp, and H. R. S. Wilkes.

3 Associates: J. Cronin, O. A. Gerber, and F. Kisbey-Green.

11 Visitors, and H. A. G. Jeffreys (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 16th October, 1920, as recorded in the October *Journal*, were confirmed.

NEW MEMBERS.

Messrs. J. Hayward Johnson and C. J. Gray having been elected as scrutineers in connection with the ballot for the election of new members, the following were declared unanimously elected:—

DIMOND, GEORGE WALTER, Jessie Mine, Bulawayo, Southern Rhodesia: Reduction Officer.
EGAN, CHARLES MICHAEL, Rose Deep Ltd., P.O. Box 6, Germiston: Reduction Officer.
FEWSTER, LOUIS LONGWOOD, Modder "B" Gold Mines, Ltd., P.O. Modderbee: Metallurgist.
LEINBERGER, KARL WILHELM, P.O. Box 1072, Johannesburg: Assistant Inspector of Mines.
PAINE, HENRY HOWARD, University College, P.O. Box 1176, Johannesburg: Professor of Physics.
ROBERTSON, ROBERT BOSWELL, Mount Ngwibi, Natal: Chemical Engineer.
DE SMIDT, SAMUEL, P.O. Box 405, Krugersdorp: Deputy Inspector of Mines.
WADDINGTON, STANLEY C., Mount Ngwibi, Natal: Chemical Engineer.
WRAITH, CHARLES OSBORN, P.O. Kaapsche Hoop, E. Transvaal: Mining Engineer. (Transfer from Associate Roll.)

The Secretary notified that the following gentlemen had been admitted by the Council as Associates:—

KISBEY-GREEN, FRANCIS, P.O. Box 101, Crown Mines, Johannesburg: Reduction Worker.
WATTS, JOHN HIGINTON, P.O. Box 27, Jeppe, Johannesburg: Tube Mill Shiftsman.

GENERAL BUSINESS.

AMENDMENTS TO CONSTITUTION AND RULES.

The President: I desire to refer to the notice on the Agenda regarding a Special General Meeting which it is proposed to call next March. The question of amending the Constitution and Rules of the Society, so as to render Past-Presidents eligible for re-election, was discussed at the Annual General Meeting in June last. Your Council has been engaged in considering this matter, and also other amendments and alterations of the Rules, and its recommendations will be put before you at the Special General Meeting referred to. In the meanwhile, suggestions from Members and Associates will be welcomed.

FIFTH ANNUAL MINING EXHIBITION.

The President: Attention is drawn to the notice appearing in the advertisement pages of the October *Journal*. The first of the Society's Exhibitions was held in February, 1912, and its success was such that we were encouraged to hold them annually, and did so up to 1914. The war prevented their continuance until January of this year, when the Fourth Exhibition, in spite of drawbacks, proved to be highly successful, being visited by some 10,000 to 12,000 people. With the increased accommodation at our disposal, we hope that next year's Exhibition will eclipse all previous ones. I wish

to appeal to mine managers and heads of departments to make special efforts to obtain exhibits.

JOINT HOUSING.

The President: The donations to the Joint Housing Account received to date amount to £265 9s. which, with the gift of £150 from our own funds, makes a total of over £400 raised by this Society. It is hoped that those who have not yet subscribed will do so at an early date.

ENGLISH V. GERMAN GOODS.

Mr. Andrew F. Crosse *(Past-President)*: I should like to make a remark or two under this heading. As you all know, gentlemen, I take up the position of being a very patriotic Englishman, but I must say I am very dissatisfied with some of the chemical products of England to-day that we are getting out here. I am talking as a chemist. Our evaporating dishes cannot compare with those we used to get from Germany before the war. Then, again—and I do not want to say too much about it—our acids are not pure, and I think it is a disgrace to our Home country that they cannot turn out the same things and of the same purity that the German firms turned out before the war. I want to bring up this matter because the unfortunate analytical chemist has not time to analyse every chemical he receives, nor can he possibly purify them; that is beyond question. So I think this question ought to be emphasised. I do not want to mention the different chemicals I have been examining and found unsatisfactory. I think if this question were made public it might be of some use.

PURIFYING WATER.

Then, I want to make another remark. I prepared a scheme some years ago for purifying the water of the Municipal Swimming Bath. If you look at this blue-print, you will see it is simply a scheme for sucking out the water from the swimming bath, taking the scum from the surface, and removing the water at the bottom, pumping it up through an air-lift pump, passing it through a sprinkler—every mining man knows about a sprinkler—and then sand-filtering it, then passing it back again to the swimming bath. If it is found the water requires a little chloride of lime, it is very easy to add it; of course, you have to add enough water to make up for the evaporation. A scheme like that would keep your bath water going for months, and you would not need to wash out the bath every week as is done now, and a great saving of water would result.

REMARKS ON BULLION SAMPLING.

H. R. S. Wilkes *(Member)*: The position of a mine assayer who does not enjoy the confidence of his manager in his ability is not likely to be a bed of roses. Conversely, one must admit that an element of doubt in the managerial mind as to the correctness of the assay results must be a constant cause of anxiety. It is often the custom to judge of the capability of the assayer by the closeness with which his bullion results agree with those of the buyers, indeed it is considered of such importance that a greater difference than one thousandth in mill gold and two thousandths in cyanide immediately calls for arbitration, the cost of which is invariably borne by the sellers.

In the humble opinion of the writer a bullion assay may possibly be a criterion of the carefulness of the assayer, but as a criterion of his technical skill it is almost worthless, since it is one of the simplest estimations he is called upon to perform. When, however, the gauge of the correctness of the assayer's result is the mean of the buyer's and the arbitrator's, then as a criterion of carefulness and skill it is worse than useless, being very often misleading, and for the following reasons:—

1. The estimations of the mine assayer and those of the buyers are never made upon the same sample.

2. The methods of sampling and the preparation of the metal for sampling here, and at Home, are rarely if ever identical.

3. Errors in describing the bars and their samples are sometimes made, and are usually outside the province of the assayer, thus the results of sample No. 1 may really be the value of bar No. 5, so to speak, and against errors of this description the assayer has no protection.

Speaking generally, the sampling methods employed on the Rand may be classed under three heads:—

1. Dip sampling.
2. Drill sampling.
3. Corner chipping.

The writer ventures to assert that these methods are not identical with those of the buyers.

We have it on the authority of Mr. Brown, of Messrs. Johnson & Mathey, that dip samples are invariably taken at home, but he added certain explanations which made it clear that even where dip samples are taken on the Rand the method is not identical with home practice. If there is a Rand smelter who stirs his bar, as Mr. Brown styles it, "to the tune of the Old Hundredth," *i.e.*, one hundred times before sampling, the writer has yet to hear of him, and if such an one exists it would be interesting to obtain data regarding the agreement of his results with those of the buyers, especially with regard to bars of low value.

With gold of 850 fine the foregoing remarks will rarely apply, it is with gold below 800 that trouble is likely to occur.

The writer lately heard of a most curious case. A bar of about 750 oz. was sent home. When the account sales arrived there was the unpardonable difference of 16 points between mine and buyer's estimations, which the trembling assayer was called into the managerial sanctum to explain. What could he say? There were the figures, and to make it worse they were in favour of the sellers. Arbitration had at once been resorted to, and the costs, of course, charged up against the sellers. Enough to shake the managerial confidence, and more than enough. Imagine the relief of the accused when, his eyes wandering over the indictment sheet, he suddenly espied that the amount of fine gold estimated by the buyers agreed with his own estimation to 0·2 of an ounce. The difference in the assay results was due to refining during re-smelting before sampling at Home. Still the buyers had rushed into arbitration, why? Meanwhile time may leave the dim memory in the managerial mind that the assayer had been indicted and was lucky to have got off, a sort of Scotch verdict of "Not proven."

To recapitulate briefly the disabilities under which the mine assayer works:—

1. Dip samples.—The best method obtaining on the Rand, but subject to errors due to insufficient stirring and wrong marking of the bars.

2. Drill sampling.—Liable to errors through liquation, especially when the metal is poured too hot, insufficient stirring before pouring, the inclusion of dust, minute particles of slag, etc., and when acid cleaned, the enrichment of the first borings (usually discarded by careful samplers), also errors in marking.

3. Corner chipping.—Subject to all of the disadvantages of No. 2, though less liable to inclusion of foreign matter.

Under these conditions the writer asks if the agreement of the mine results with those of the buyers is a fair criterion of the assayer's skill?

Incidentally, the writer would timorously suggest that the possibility of a mixing of sample numbers may occur in the buyer's offices. As before stated, all the above-mentioned disabilities are lessened in degree as the fineness of the gold improves, and this explains why it is so seldom that wide differences occur, Rand bars being usually well over 850, but the writer suggests, and this is the reason for these remarks, that, especially in view of the approaching establishment of a local refinery, a standard method be adopted first for the preparation of the metal for sampling, and, secondly, for sampling.

The President: I can speak rather feelingly on this question, because once or twice after sending gold to England, I have found that my weights did not agree with the London weights and, although probably it was only a few pence per bar, the very fact that there is a discrepancy arouses a certain amount of uneasiness, not only in your own mind with regard to your own officials, but sometimes suspicion with regard to the buyer's accuracy. As Mr. Wilkes points out, when our refinery is started, it would certainly be advisable to get a standard method in all the assay offices along the Reef.

Mr. J. Hayward Johnson *(Member of Council)*: I think Mr. Wilkes is to be congratulated on bringing up this point. The assayers along the Reef suffer very great disabilities. I think not only a standard method of sampling, but a standard apparatus should be used, because you will find in some of the old assay offices they are still using a glass apparatus, while in some of the better offices they are using the platinum apparatus. All these things tend to cause differences which to the lay mind are not readily realised, and the assayer on one of the poorer mines is very apt to be misjudged through no fault of his own.

Mr. John Watson *(Member of Council)*: For a period of 15½ years I was chief assayer on the City and Suburban mine and did the gold bullion assays. Only once was there a serious discrepancy with London over the weight of a bar of gold. In that case a

clerical error had been made in London, and the figures first reported to us referred to a bar from another mine. Before the South African war I knew of only two large platinum parting apparatus on the Reef—those at Langlaagte Estate and the City and Suburban mines. The complete apparatus cost about £80 in the early 'nineties, and was looked upon as more or less of a luxury. I exhibited the "City" apparatus one evening at a meeting of the S.A. Chemists' Association about five years ago; its value then had become enhanced, so that, at the price then current for platinum, it was worth about £350. The City and Suburban Co. had it in use for something like 25 years. It was still sound when I last saw it, so had proved a really good investment.

NOTES ON EXPERIMENTS ON VENTILATION PROBLEMS IN DEVELOPMENT WORK ON MINES.

By E. J. Laschinger, M.E., B.A.Sc. (Tor.), M.I.M.M.

Early this year a sub-committee was appointed by the Prevention of Accidents Committee to investigate and report on mine rescue work, gassing accidents, etc., on the gold and coal mines of the Transvaal, and the writer was invited to give his views on the engineering aspects of the problem, more especially with reference to compressed air and ventilation problems and to assist the committee in regard to this side of the question.

During the course of the deliberations of this committee the question arose as to the amount of fresh pure air required to clear out fumes after blasting in order to render the air wholesome in dead ends.

Facilities were provided by Mr. J. Whitehouse (Manager of the Village Deep, Limited) and certain tests were carried out in the Village Deep mine, the details and results of which are given in the following excerpts from the writer's report:—

The object of certain experiments carried out was to obtain data as to the amount of fresh air required to clear out fumes after blasting in a development drive.

The experiments were conducted on the 27th Level West of the Village Deep, Ltd. The first experiment was made on the 15th April, 1920; but owing to a reasonable doubt as to the accuracy of the air measurements, several other tests were made, with a final test on the 22nd September, 1920, which it is firmly believed gave accurate and reliable data.

In this test the konimeter, sugar-tube, CO_2, and temperature readings were in charge of Mr. E. F. V. Wells, the Underground Manager, and his report is annexed hereto.

AIR TEST, 27 WEST DRIVE, TURF SHAFT (Annexure A).

Temperature Fahrenheit.			Konimeter. Counted in Particles per cub. centimeter.			Sugar-Tube.		CO_2.	
Time.	Dry.	Wet.	Time.	Total.	Above 5 Mks.	Time.	Weight of dust in M.Gr. per cub. metre	Time.	Per cent. CO_2.
			4.24	Nil					
			4.25	80					
			4.30	4,000		4.27	2·4	4.28	0·48
4.15			4.35	4,000		4.36	156·9	4.37	0·42
to	82·0	81·8	4.43	3,000		4.42	82·8	4.50	0·48
5.45			5.0	2,000		5.1	16·8	5.2	0·46
			5.20	500					
			5.38	400		5.30	3·6	5.31	0·13
			5.45	300		5.43	1·2	5.44	0·08

Blasting time, 4.15 p.m.
Drive clear at 5.45 p.m.
Total time to clear drive of dust and smoke, 90 minutes.
Volume of air displaced, $1{,}620 \times 6 \times 7 =$ 68,040 cubic feet.

Explosives used—
Gelignite ... ... 30 lb.
Gelatine ... ... 60 lb.
90 lb. in all.
Fuse ... ... 90 ft.

Length of Drive, 1,620 ft.—
Area of drive... 6 ft. × 7 ft.
Size of Air Pipe, 3 in.=7·07 sq. in. area.

Openings at end of pipe—
5— 1 in. taps=3·929 sq. in.
3—3/16 in. taps=0·0829 sq. in.
Total 4·01 sq. in.

22nd September, 1920.

(Signed) E. F. V. WELLS,
Underground Manager.

The air measurements were taken by Mr. D. B. McLaren under my own supervision. A sharp-edged orifice plate meter was used, one of a standard type used by the Rand Mines, Limited, Air Testing Department.

The principal results are as follows:—

Temperature of air, 82° F.

Air pressure in pipe 53 lb. to 66 lb. sq. in. gauge, average pressure 58 lb.

Barometric pressure 14·7 lb. sq. in.

Flow varied from 102 lb. to 84 lb. of air per minute, average flow 93 lb. per minute.

Average flow at 14·7 lb. barometric pressure 1,265 cub. ft. of free air per minute.

Total air discharged in 90 minutes, $1{,}265 \times 90 = 113{,}850$ cub. ft.

Capacity of drive=68,040 cub. ft.
Therefore air in drive was displaced 1·67 times.

Velocity of ventilating air in drive, $\frac{1{,}265}{42} = 30$ ft. per minute.

Another test was conducted a few days before, but without the air measurements, and it will be seen that the results are similar. See Mr. Wells' report (Annexure B).

AIR TEST, 27 WEST DRIVE, TURF SHAFT (ANNEXURE B).

AIR PRESSURE.		TEMPERATURES. Fahrenheit.			KONIMETER. Count in particles per cub. centimeter.			SUGAR.		CO_2.	
Time.	Lbs. per sq. in.	Time.	Dry.	Wet.	Time.	Number under 5 Mks.	Above 5 Mks.	Time.	Weight of dust in M.Gr per cub metre.	Time.	Per cent. CO_2.
4.15	54				4.19	Nil.					
4.20	44				4.20	60		4.25	0·6		
4.30	46	4.30	83·1	83·0	4.33	190	3			4.27	0·16
					4.34	270	2				
4.43	50				4.45	1,800		4.43	37·5	4.45	0·47
		4.50	83·5	83·4	4.46	4,000					
4.50	53				5.2	2.000	15	5.0	33·0	5.1	0·39
					5 3	3,000	20				
					5 20	500	—	5.18	19·0	5.19	0·31
					5.35	370	7				
5.42	56	5.42	83·75	83·65	5.42	320	6	5.40	7·5	5.41	0·11

Length of drive, 1,600 ft.

Area 6 ft. × 7 ft. Area of drive 67,200 cub. ft.

Blasted at 4.12 p.m. Total time to clear drive of gas and dust=1 hour 30 minutes or 90 minutes.

Drive clear 5.42 p.m.

Explosives used—

Gelignite	... ...	40 lb.
Gelatine	... ...	40 lb.
Fuse ...	... ...	72 ft.

Size of air pipe 3in.=7·07 sq. inches.

Openings at end of pipe—

5—1in. taps=3·929 sq. in

3—3/16 in.=0·0829 sq. in.

Total 4·01 sq. in.

Average air pressure, 50 lb. per sq. in.

24th September, 1920.

(Signed) E. F. V. WELLS,
Underground Manager.

(Check without measuring air, test on 17th September, 1920.—E. J. L.)

In the test of the 15th April, 1920, the length of drive ventilated was only 1,050 ft., but the air meter readings were probably wrong; however, it is possible to calculate the air flow by data given in the last te by applying the necessary corrections for differences in condition, which are principally:—

(1) Difference in length of pipe.

(2) Difference in pressure of air.

Barometric pressure and temperature were practically the same in both cases.

Flow varies inversely as square root of pipe length, directly as the square root of the mean absolute pressure and directly as the square root of the drop in pressure. The factors by which to multiply the result of the test of 22nd September in order to get the result for the 15th April would therefore be:—

For length of pipe—

$$\sqrt{\frac{1,620}{1,050}} = 1{\cdot}243$$

For mean pressure—

$$\sqrt{\frac{77{\cdot}7}{72{\cdot}7}} = 1{\cdot}034$$

For pressure drop—

$$\sqrt{\frac{60}{55}} = 1{\cdot}044$$

Total ratio=1·347.

Probable flow 15th April, 1,265 × 1·347= 1,700 cub. ft. per minute.

In this case the drive was cleared in 48 minutes and total fresh air

1,700 × 48=81,600 cub. ft.

Capacity of drive=1,050×42=44,100 Therefore air in drive was displaced 1·85 times, according to calculation.

From the above it seems reasonable to assume that the air in a drive or working place should be displaced, say, $1\frac{3}{4}$ times by fresh air in order to clear the fumes and dust of blasting.

It is also evident that the time required to clear a drive of fumes by means of compressed or ventilating air will vary:—

(1) Directly as the length of the drive.

(2) Directly as the square root of the length of ventilating pipe, with other conditions equal.

Therefore, under similar conditions of air pressure in the pipes, the time required will vary as the square root of the cube length, *i.e.*:—

Time varies as $L^{\frac{3}{2}}$.

Stated roughly, twice the length of drive requires three times as long to clear and three times the length over five times as long.

It follows, therefore, that the time required in any particular mine to clear the air will depend upon the time required to clear the longest drive, and this is governed largely by the size of pipe and pressure of air. Since compressed air is expensive, it is essential to cut down the time of blowing out as much as possible to avoid waste of air. The size of air pipe should therefore bear a certain relation to the length of the drive, *i.e.*, the longer the drive the larger the air main required. Theoretically, the object to aim at is to have all the drives cleared at the same time, and this means

that the longer the drive the greater the rate of air flow required. In a table which I calculated out in January last, copy of which is attached (Annexure C) the discharge of air is given for certain conditions for 1 in., 2 in., 3 in. and 4 in. pipes.

PROBABLE AIR DISCHARGE THROUGH PIPES.

Premises—Temperature of air 70° F.
Gauge pressure at inlet 80 lb. sq. in.
Barometric pressure 12 lb. sq. in.
End of pipe open to atmosphere.

Length of Pipe Ft.	Quantity Cub. Ft. Free Air Per Minute. 1in. Pipe.	2in. Pipe.	3in. Pipe.	4in. Pipe.
1	1,056	4,224	9,504	16,892
100	282	2,050	6,420	13,900
200	208	1,510	4,740	10,260
300	170	1,240	2,870	8,400
400	147	1,070	3,350	7,260
500	131	953	2,980	6,460
600	120	874	2,740	5,930
700	112	815	2,550	5,540
800	104	757	2,370	5,140
900	99	720	2,260	4,880
1,000	93	676	2,120	4,590

For any other lengths the quantities are in inverse proportion to the square root of the relative lengths.

NOTE.—It is probable that the 1 in. pipe would discharge 20% to 30% more than the figures given. At the altitude of the Rand there are 16 cub. ft. of air per lb. weight.

(Signed) E. J. LASCHINGER.

6th January, 1920.

For other conditions the flow in cubic feet of free air per minute will vary:—

(1) Inversely as the square root of the length of pipe.
(2) Inversely as the barometric pressure.
(3) Directly as the square root of the mean absolute air pressure.
(4) Directly as the square root of the drop in pressure.
(5) Directly as the square root of the absolute temperature.

By comparing the results of this table, assuming the conditions of the actual test and making the necessary corrections, the flow would be 1,100 cub. ft. free air per minute instead of 1,265 actually measured; thus showing that the figures in the table (Annexure C) are about 15% on the low side.

In conclusion, there is a practical recommendation that I would make, and that is to instal a 4 in. pipe in all drives that are to be more than 1,000 ft. long. This practice was carried out on several mines on my recommendation about 12 years ago, not on account of ventilation, but for drilling efficiency, and the results proved the soundness of the practice. When the drive is short the amount of air blown through can easily be regulated by the number of nozzles left open at the far end. I could recommend this practice of blowing out with compressed air only for dead ends and not for stopes or other places, which should depend for their clearing out on ventilating currents actuated by fans, or natural ventilation if sufficient, and suitably split and controlled by bratticing and air gates where necessary.

It may be mentioned here that the calculated air discharges were afterwards checked by measurement at the surface against a standard air meter and found to be in substantial agreement.

During the course of the experiments underground the writer personally investigated the effect of the low air pressure on the usual water-blasts, and found that they were not effective in giving the spraying action that is considered essential in the solution of nitrous fumes and allaying of dust.

It appeared to the writer that considering the high velocity with which air will emerge from a nozzle even at as low a pressure as 1 lb. above atmospheric pressure, an atomising device might be designed to give effective results. Such an experimental device was evolved and tried, and the results are depicted by the following photographs:—

General data as follows:—

Air Orifice.—1 in. gas tapped, such as is usual for connecting the hose for a large drill, *i.e.*, 1 in. hose.

Water Orifice.—⅜ in. gas pipe flattened; end of water pipe placed centrally in stream of air 5 in. from orifice and inclined at an angle of 30° to line of air flow.

Photograph No. 1 shows a stream of water amounting to 0·78 gallons per minute without air current.

Photograph No. 2 shows same with air turned on at 1 lb. sq. in. pressure. This atomised the water and projected the spray to a distance of 35 feet.


2.
3
4.
5.
6.

Photograph No. 3 shows a stream of water of 2·63 gallons per minute without air current.

Photograph No. 4 shows the same as No. 3, but with air turned on at 5 lb. per sq. in. pressure. In this case the spray was very heavy at 35 ft. distance, and would have carried much further, but was obstructed by a galvanised iron fence.

Photograph No. 5 shows the same as No. 4, but the air pressure raised to 15 lb. per sq. in., and gives a denser spray projected with higher velocity, the quantity of water remaining the same, *i.e.*, 2·63 gallons per minute.

Photograph No. 6 shows the pressure reduced to 1 lb. per sq. in. with 2·63 gallons per minute of water. The amount of atomised water is very little in excess of that shown in Photograph No. 2, the bulk of the water falling in large drops about 10 ft. in front of the nozzle. It was hoped that this rain of large drops would show up in the photograph. but unfortunately this was not the case, because although the exposure was only 1/50 second, the direct sunlight vanished just as the snap was taken and this was not observed at the time.

Although the above experimental apparatus would not be applicable underground, it demonstrates that a strong and serviceable spraying unit can be designed which will be effective even with very low air pressures.

Leaving out of consideration the effect of water-blasts and sprays, it is evident that a certain amount of fresh, clean air is required to displace the foul and dusty air in order to make the working place " fit to live in." The experiments show that the amount of displacement should exceed the cubic space by, say, 75% when the water-blast is ineffective as a spray. Since water sprays cannot always be depended on, the rule of displacing the foul air by nearly double the cubic capacity of the space to be cleared is a safe one. The water spray if in action should improve the conditions.

The Mining Regulations lay down that every winze, raise, etc., shall be blown out by compressed air before anyone enters the working place, except for inspection. It is, of course, evident that the time required to clear a development end will depend upon cubic space and rate of air supply. What would take half-an-hour in one case might be done in five minutes in another or take two hours in a third case.

We now come to practical methods of displacing foul air at the least cost. There are two methods :—

(1) Using compressed air from the mains.
(2) Using low pressure fans or blowers actuated by compressed air.

Both methods have been tried for some years on the Rand, and comparative figures of cost can be obtained from actual practice

Engineers for years past have called attention to the high cost of compressed air for ventilation, and the writer himself has pressed this point often. It is, of course, evident that if the whole of the extensive working of a mine, with the large volume of all the workings, were to be ventilated by compressed air, the cost would be enormous. Fan ventilation is the proper thing for displacing the air of the workings as a whole. We are now, however, considering the problem of displacing the foul air of dead ends only.

(1) Using compressed air for ventilating dead ends.—On the Central Rand the compressed air delivered at 100 lb. per sq. in gauge pressure costs 0·525 pence per unit when purchased from the Rand Mines Power Supply Company, Limited, a unit representing about 440 cub. ft. of air at ordinary barometric pressure. To ventilate a drive, say, 6 ft. × 7 ft. × 1,000 ft. long and displacing the air say $1\frac{3}{4}$ times would cost about 8s. 4d. per shift.

(2) Using fan or ejectors and ventilating piping.—Cost of compressed air per shift 10d. Ventilating piping (canvas or G.I.) :—

1000 feet at 2s. 6d.	£125
Ejector and booster	5
	£130

	Cost per Shift
Life of piping, 5 months, say, 130 shifts	240d
Maintenance per shift	20d
Compressed air	10d.
Total per shift	270d

Cost 22s. 6d. per shift.

Saving by compressed air 14s. 2d. per shift.

These are, of course, only rough figures, but are quite decisive in upholding the

soundness of the practice which has been pursued at such mines as the Village Deep for some years.

A warning note must be sounded, however, with regard not to the use, but the abuse of compressed air. If the air be not shut off from drives after the ventilating period is completed there is the danger of blowing off air from 4 p.m. till 7 a.m. next day at, say, 8s. 4d. per hour for each drive. This, of course, would make the case for compressed air ventilation look very sick.

The method pursued at the Village Deep and some other mines is to cut down the air pressure at the surface after blasting time, and after a certain period of blowing out the compressed air is shut off altogether. On some mines where air is required between shifts, such as for sinking and pumping, the air is cut off entirely at the shaft stations from drives where air is not required after blowing out.

There are many cases where it would pay to run a separate air pipe down to the working place such as in incline shaft sinking and cut the main air supply off definitely at the surface so as to prevent waste owing to valves and cocks having been left open which should have been closed. It has often happened that a 500 h.p. compressor has had to be kept running to work a small air pump below during the night.

The writer wishes to take this opportunity to impress upon the members of this Society, more especially those who have to do with the mining end, the great necessity of preventing waste of compressed air, because in these days especially it is so necessary to economise. Care and attention in the use of air power and the prevention of waste and leakage will effect savings in mining costs much greater than most mining men, not to mention the miners themselves, realise.

In conclusion, I beg to thank your Society for the opportunity of again presenting a paper before you after the lapse of many years.

Mr. C. J. Gray *(Member of Council)*: I should like to welcome Mr. Laschinger back to active participation in the affairs of the Society. He did a great deal for the Society in the past. We all hope he will favour us, in the future, with more of hi valuable information.

Mr. Laschinger's paper is a very useful one. It deals with a matter which is of live interest, and which, it so happens, is being investigated by a Committee of Inspectors of Mines. It will be interesting to see whether the results obtained by the Inspectors correspond exactly or approximately with those obtained by Mr. Laschinger.

Experience has shown that the condition of the air in development drives at the commencement of the lashing shift—that is, on night shift, after blasting—has been very far from good, in spite of the numbers of water blasts which are sometimes put in. In one case no less than five water-blasts were in the drive, but some considerable time after the blast the air was found charged with exceedingly fine blasting dust. The reason is that, although the water-blasts, if tested singly during the shift, would prove perfectly effective, throwing a large spray, conditions are different between shifts. All the water-blasts in the mine are then turned on, the air pipes are turned on in the winzes, and the air-pressure or the air-flow is reduced at the surface in order to save compressed air, and then water-blasts are not really effective, as there is insufficient air to supply all demands. A certain amount of water issues from the water-blasts which is not atomised; which is not thrown into the air. There is a limit to the amount of compressed air which can be supplied with any reasonable economy; and water-blasts which will be economical with compressed air are far more likely to give real, valuable effect in reducing dust than those which are extravagant and which we cannot expect to be used as they should be.

The question of the water-blast is closely connected with that of ventilation of the drives. If the drives could be ventilated so thoroughly that all the blasting dust would be carried out, the need for the water-blast would be small. It would be needed to a certain extent for wetting the broken rock and wetting the sides of the drive. What is the best and most practical method of doing the work, whether by ventilation or the water-blast is now under investigation.

Mr. Laschinger has shown us illustrations of water-blast tests. It struck me that possibly the effect of a water-blast on the surface is not exactly the same as the effect underground in practically saturated air. I do not know whether Mr. Laschinger can give us some information on the point. Probably he has taken it into consideration.

His whole paper illustrates the need for exact information with regard to questions of ventilation. They are exceedingly complicated, and very often mining men have to act by rule of thumb.

I propose a hearty vote of thanks to Mr. Laschinger for his most interesting and valuable paper.

Mr. M. J. Thorp *(Member)*: Mr. Gray's remarks in proposing a vote of thanks to Mr. Laschinger for his paper have left very little to be said. Certainly the paper has given us something to think over and discuss. If we go thoroughly into the matter of calculating the amount of air to be displaced twice over when we have drives as far as 2,000 ft. beyond the last winze and raise connection and then take the capacity of our compressors, we shall find we need to run them quite a long time.

There is one point in connection with Mr. Laschinger's remarks to which I should like to refer. He was suggesting separate air pipes when high-pressure air is needed for other purposes during the blowing-out of dead ends. I think it is a generally adopted practice that direct pipes are installed from the receivers on the surface down to the pumps, winches, etc., that are to be kept working during the period of ventilating, so that the pressure need not be kept up in the whole of the air mains.

I should like to second Mr. Gray's vote of thanks.

Mr. H. R. Adam *(Member of Council)*: I should like to ask two questions in connection with Mr. Laschinger's paper which, although perhaps only indirectly connected with his subject, are of considerable interest. He referred to a test on the Village Deep, and said Konimeter and sugar tests were made. I would like him to tell me how these tests compared. The second question is, was any opinion arrived at as to whether the air blown in raised any dust which had settled?

The President: I should like also to thank Mr. Laschinger for his very interesting paper, especially that portion dealing with the long lengths of drive. It used to be quite a common experience in going into a drive at night to go through a tunnel laden with fumes and dust until you got to the comparatively clear air at the face. I remember conducting some experiments for the Phthisis Prevention Committee at the Turf Shaft. I got through the drive very well, but some economical soul at the other end cut off the air. The air became too thick, and I and my boys were gassed. This was some years ago, and was probably due to the fact that nobody then realised what quantity of air was necessary to displace the air in the drive. The air had been on for about two hours, but it certainly did not displace the gas. We now realise that the air must be displaced twice, which I think is a very important fact. It might be thought at first that if it were displaced once that would be quite sufficient, but apparently that is not so.

There is one great difficulty, too, in dealing with air pressures and water pressures, especially at the end of the shift. Unfortunately all the sprays are turned on at once, and it means that those sprays that are nearest the surface get very little water; those that are at the bottom—the lower sprays—get most of it, and it is almost impossible to prevent that sort of thing. That accounts for there being so many drives in which the dust is so badly laid. However careful a manager may be, you will find that constantly happens. Sometimes a man goes out and forgets to turn on his spray; sometimes something goes wrong with it right at the end of the shift. All these things tell against the purity of the mine air. The work that has been done by Mr. Laschinger is being continued by the Inspectors' Committee, and I am certain that in the near future a perfect water system will be devised. I have very great pleasure in thanking Mr. Laschinger for his paper.

Mr. J. A. Woodburn *(Member of Council)*: There is only one point I should like to bring forward in connection with the remarks on the displacement of air. It seems to me that although a certain quantity of air is exhausted from the main pipes equal to, say, twice the volume of air in the drive, one cannot call that absolute displacement. Air is not like a solid mass which could be pushed out of the drive by the air coming from the pipes. It is more in the nature of diffusion. So that you can hardly speak of displacing the air in a long development end. The practice of ventilating by compressed air from pipes is one that cannot be recommended. For short winzes it may be all right, for long development ends it may be of assistance, but it is only of assistance, and the assistance is very expensive.

Drives of 1,600 ft. to 2,000 ft. without air

connection should be the exception and not the rule. Some attempt has been made recently to drive double drives, one in the footwall and the other in the reef, and connections can be made much more frequently, and an extension of this system seems to me to be the solution of thorough ventilation in the mines on these fields.

Mr. E. J. Laschinger *(Visitor):* I understand the usual rule in this Society is for the author to wait until all the discussion is finished before replying to the discussion. Considering the few questions which were asked, I might answer these briefly.

With regard to the method of sampling, this was done in the usual manner by the dust sampling staff, including the konimeter, sugar and carbon dioxide tests. It seems unusual to have such a large amount of dust at the end of a long development drive so shortly after blasting, and it is quite probable that a large amount of this dust was shaken from the walls of the drive by the concussion due to blasting.

Concerning the question as to the difference between air at the surface when the sprays were tested and the air underground, I might say that the experiments on the sprays were made on a rainy day and the degree of saturation was about similar on both occasions as taken by the records of the dry and wet bulb thermometers.

The principal point of the paper, and that which was considered more particularly by the Sub-Committee on Ventilation and clearing out of fumes and dust in development drives, is that the ordinary water sprays in general use would not be ineffective when there is low air pressure, that is, when all the air is turned on full in the development drives. It was for this reason that the experimental spraying apparatus was designed in order to see whether a pressure of as low as 1 lb. per sq. in. would be sufficient to make an effective spray. From the photographs and descriptions of these sprays, I think it will be agreed that the operation was quite successful, and this I think would be corroborated by Mr. Whitehouse, whom I took round to have a look at the spray at the test plant. At the lowest pressure the spray was very effective at a distance of 35 ft. and very heavy at a pressure of 5 lb. per sq. in.

With regard to having development drives open at both ends and avoiding any long drives, I do not see how this could be carried out in practical mining except at very high expense. It should make no difference in the clearing of the drive, no matter how long, if there is sufficient fresh air pushed into it in order to clear the fumes and dust in a reasonable time. There will always be a certain number of dead ends in mining, and if these can be kept clear cheaply with compressed air there is no use in going to elaborate arrangements and high expenditure in order to keep the drives always short.

THE KATA-THERMOMETER AND ITS PRACTICAL USES IN MINING.

By H. J. Ireland, M.B.E., B.Sc., A.M.I.C.E.

I have much pleasure in setting before this Society the merits of Hill's kata-thermometer, as I feel that this instrument is not as fully known and appreciated as it should be.

The kata-thermometer is an instrument invented and designed by Professor Leonard Hill, the well-known physiologist, for measuring the cooling power of the atmosphere, a property which Dr. Hill's researches have established as having a most important effect on human health and efficiency. Before further describing the instrument, it will help you to appreciate its purpose and uses if I briefly outline the researches which led up to its introduction.

Dr. Hill and his colleagues carried out a series of exhaustive experiments,* in one class of which he had seven or eight students shut in an air-tight chamber of about three cubic metres capacity, which was provided with electric fans for stirring up the air, and the temperature and humidity of which could be varied as desired. In one experiment they were kept there till the CO_2 content had reached 3 or 4 per cent., and the oxygen had fallen to from 16 to 17 per cent., the air failing to support combustion of a lighted match; the wet bulb temperature had risen to about 83 degrees F., and dry bulb a little higher.

* See Report on "Ventilation and Effect of Open Air and Wind on the Respiratory Metabolism" to Local Government Board, 1914.

The discomfort was considerable, pulse rate high, faces flushed, skin and clothes moist with sweat. *Stirring up the air by means of the fans gave immediate relief,* and lowered the pulse rate from an average of 97 per minute to 79, though no fresh air from outside was admitted. Persons in the chamber breathing fresh air from outside through tubes were not relieved, and persons outside breathing the "vitiated" air of the chamber experienced no discomfort. The sudden introduction of CO_2 from a bag to a percentage of 2 was not discerned by the inmates of the chamber.

In another class of experiment guinea pigs were made to breathe continuously for several weeks the exhaled air of rats, and when inoculated with rat serum showed no signs of having been sensitised to it, thus demonstrating that there were no proteid toxins in the exhaled air.

A great many experiments were also carried out to determine what effect different atmospheric conditions, exercise and rest, had on the respiratory metabolism, that is, amount of oxygen absorbed and CO_2 expired. I am afraid there is not time to describe these.

The outstanding results may be summarised as follows:—

(1) Stuffiness of air is due principally to heat stagnation, that is warmth, humidity and stillness; and to make air comfortable and refreshing it should have considerable cooling power, that is the temperature should be reasonably low, the air dry, and in motion.

(2) The CO_2 even up to one per cent. has no appreciable effect on a resting person, and only causes deeper breathing in a person doing muscular work. (Yet ventilation standards are still held by some authorities requiring CO_2 content of rooms to be kept within four or five parts in 10,000 above outside air, or, say, an average of ·09 per cent.).

(3) There is no evidence of organic toxins in exhaled air.

(4) The metabolism of the body is substantially increased, waste products better eliminated, general health and immunity from disease promoted, by living in air of low temperature, dry and in motion.

Dr. Hill has substantiated these results from practical life, and has shown from statistics that persons employed in outdoor occupations, other things being equal, have greater immunity from diseases (particularly those of the respiratory organs), than those who live and work in close, stuffy atmospheres.

With regard to CO_2 it is pointed out that in aerated water factories and breweries where in some parts the air contains 1·5 to 2·5 per cent. of CO_2, the workers seem to suffer no bad effects from breathing this air for several hours each day.

Before leaving this digression into physiology, I would just remind you of a few elementary physiological facts which closely affect the subject. In warm-blooded animals all muscular activity is accompanied by a production of heat due to oxidation or combustion of carbon in the body, the carbon being chiefly in the form of glycogen or muscle sugar. The heat production is least when the body is resting or doing internal work only, such as the action of heart, lungs, digestive and eliminative organs, and is considerably increased when external work is done. It is evident that if the heat is not got rid of as quickly as produced, the body temperature will rise and produce fever symptoms. The body has a marvellous heat-regulating mechanism which acts—

(1) By varying the blood circulation near the surface of the skin, thus varying the heat lost by radiation and convection;

(2) By varying the output of moisture through the skin and consequently the heat lost by evaporation.

This heat-regulating mechanism will make desperate efforts to keep the body cool if it is physically possible, but it can of course be over-strained and fatigued.

I should also mention that a considerable amount of heat is lost by evaporation from the respiratory tract, particularly in cool, dry atmospheres, which have a low moisture content; it is greatly conducive to the health of the respiratory organs to give off a large amount of moisture as it promotes the flow of immunising fluids from the lymphatic glands to the mucous membrane.

One of the problems of the gold mining industry is to provide sufficient cooling power in the air of the workings to permit the workers to work comfortably and efficiently and without straining the heat-regulating mechanism by excessive sweating,

etc. This problem becomes more acute as the operations are carried to deeper and hotter parts of the reef.

The problem of improving working conditions in hot, humid atmospheres has engaged the attention of several investigators for some years now, particularly in the weaving and spinning sheds of Lancashire, but nearly all have either neglected the effect of air currents or treated this effect as incidental. One authority takes the wet bulb temperature as a standard of comfort, and fixes 75 degrees F. wet bulb as the permissible maximum for spinning mills and weaving sheds, etc., and states with regard to mines that when "the wet bulb exceeds 85 degrees F., hard work in a mine seems hardly possible." Another authority states that attempts to judge conditions by wet bulb are misleading, that dew point is a better indicator, and that "in any case dew points of 70 degrees and over give rise to most oppressive conditions." In this connection I may state that it is possible to keep a man reasonably cool a· comfortable, working in an atmosphere with dry bulb 86 degrees, wet bulb 85 dgrees F. (*i.e.*, nearly saturated) dew point 84·4 degrees F., provided we fan him with an air current at 380 feet per minute (or just under two metres per second).

It remained for Leonard Hill to give cooling power, and particularly air movement, their rightful place as factors in good air conditions, and to determine the quantitative effects of temperature, humidity and air movement.

It is almost impossible in connection with work in the mines to overstate the importance of *movement* in the air. Due to convection of heat from the rock and the evaporation of moisture from water applied to keep down dust, it will be difficult, if not impossible to increase considerably the cooling power in the workings from the factors of temperature and humidity, and the only factor remaining is that of air movement.

Mr. D. Harrington, Mining Engineer of the U.S.A. Bureau of Mines, appreciates the value of air movement, and in a recent article says: "In the ordinary metal mine the velocity of air at working faces is much more important than humidity temperature and content of gases, except when the two latter go to extremes. For example, men have climbed 100 feet out of a stope with pure still air at 79 degrees F. and 86 per cent. relative humidity to 'cool off' in a level where the air was 3 degrees hotter and 5 per cent. more humid than in the stope, but was moving with a velocity about 150 feet per minute." I shall refer to these figures later when dealing with definite values of cooling power. It should be borne in mind that in the factor of air movement, every eddy and to-and-fro movement counts, which will help to remove the layer of warm humid air from the clothes or skin, though it may not be measurable by an anemometer. (The kata-thermometer is sensitive to all such eddies.) It is obvious, moreover, that if the wet bulb temperature is as high as that of the body, no benefit can be effected by moving the air. t < 36.5°

Having established the importance of cooling power in healthy atmospheric conditions, Dr. Hill set out to devise an instrument to measure it.

The instrument is an alcohol thermometer having a large cylindrical bulb about 4 cm. long and 2 cm. diameter, with a stem graduated from 95 to 100 degrees F. (See Figure 1.) The range 95 degrees to 100 degrees is arbitrarily chosen to give a mean temperature of 97·5 degrees F. (or 36·5 degrees C.), which is approximately that of the clothed body surface. A small reservoir is provided at the top of the stem to give a margin for overheating without bursting the bulb, and to ensure that the cooling has settled down to a steady rate when the meniscus is falling from 100 degrees to 95 degrees.

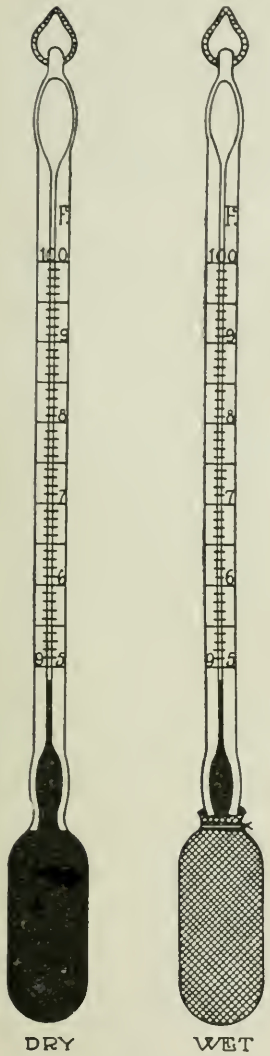
To take a reading of dry cooling power the bulb is used bare, and heated in water (about 80 degrees C.) until the alcohol rises into the top reservoir. (A thermos flask is very convenient for holding the water and keeping it hot through a short series of readings.)

The bulb and stem are then dried and the instrument suspended in the place required. The time in seconds is taken (preferably by a stop watch) for the meniscus to fall from 100 to 95 degrees. To take the wet cooling power the thin stockingette finger-stall supplied with the instrument is drawn over the bulb which is heated in hot water as before, the surplus water is then shaken off, the instrument suspended and the time taken.

When I first used the kata some five years ago the instruments were not standardised as at present, but readings of time were given for wet and dry kata on the

* Metal Mine Ventilation. Safety Engineering August, 1920.

FIG I.



THE KATA — THERMOMETER.

instruction sheet for various conditions, the standard being what Dr. Hill called "an ideal spring day"; that is, bright, clear and sunny with air temperature about 60 deg. F. and a light fresh breeze blowing. One had to judge the conditions under test by comparing the times with those given for the ideal conditions. Since then Dr. Hill has devised a method whereby each instrument will give readings of the wet and dry cooling powers in definite units. Each instrument is carefully calibrated and marked on the back of the stem with a "factor" or co-efficient so that the factor divided by the time in seconds of cooling from 100 to 95 degrees gives the cooling power in millicalories ($\frac{1}{1,000}$ gram calories) per sq. cm. of cooling surface per second.

If H = cooling power in millicalories per sq. cm. per sec.:

K = factor of instrument.

T = time in seconds for meniscus to fall from 100 to 95 degrees.

Then $H = \frac{K}{T}$

As a rule several readings, say, five of each kind, should be taken and the average of these taken as the cooling power.

For healthy conditions Dr. Hill recommends the following dry and wet cooling powers:—

(1) Dry 5 to 7, wet 16 to 20, for sedentary occupations;

(2) Dry about 8, wet about 25, for lignt manual work.

(3) Dry about 10, wet 30 to 35, for heavy manual work.

These figures are, of course, approximate, and will vary somewhat with the individual, and what is taken as light or heavy work.

My experience in the testing of ventilation in Government buildings in London bears out these figures, particularly the first two sets.

A higher wet cooling power does not entirely compensate for a low dry cooling power, as this requires a fair amount of sweating to give sufficient cooling. An instance of this occurred on a Sunday last month when I took some readings on my verandah; the dry bulb temperature was 85 degrees F., the wet 56 degrees F., dry kata cooling power 3·22, wet kata 24·3. While resting one felt uncomfortably hot; moving about and exercising intermittently gave relief by inducing more perspiration, and thus getting advantage of the high wet cooling power. Such conditions have a danger of producing chill when one is resting after hard exercise.

The heat loss per sq. cm. of the human body lightly clothed may be taken on the average as about one-sixth of the dry kata cooling power, and is about 60 per cent. of the heat loss of the naked body. For a man working stripped to the waist a kata cooling power of six will have much the same effect as a kata cooling power of 8 to 10 for a man

lightly clothed. We find in practice that a dry kata cooling power of 6 and wet about 18, though not perhaps ideal, is sufficient to keep a native fairly cool and comfortable when stripped to the waist, and doing hard manual work underground, without any appreciable falling off in output from that performed in cool conditions on the surface.

To determine the laws governing the relations between wet and dry cooling powers and factors of temperature, humidity, velocity of air, and barometric pressure, Dr. Hill had a series of experiments carried out in which kata readings were taken with variation of all these factors. The following relations were established:—

Let Hd = cooling power of air in millicalories per sq. cm. per second by dry kata.

Hw = ditto by wet kata.

t = temperature of air, in degrees Cent.

θ = excess of kata temperature over temperature of air $= 36{\cdot}5 - t$.

V = velocity of wind in metres per second.

F = vapour tension in mm. of mercury at temperature 36·5° C. = 45·6.

f = vapour tension of the atmosphere.

Then in still air $Hd = 0{\cdot}27\ \theta$. (1)

or $\dfrac{Hd}{\theta} = 0{\cdot}27$. (1a)

in wind $Hd = (0{\cdot}27 + 0{\cdot}49\ \sqrt{V})\ \theta$ (2)

or $\dfrac{Hd}{\theta} = 0{\cdot}27 + 0{\cdot}49\ \sqrt{V})$ (2a)

in still air $Hw = Hd + 0{\cdot}085\ (F - f)^{\frac{4}{3}}$ (3)

0.08

in wind $Hw = Hd + 0{\cdot}102\ V^{0{\cdot}3})\ (F - f)^{\frac{4}{3}}$ (4)

The cooling power say, H_2 at any temperature t_2 other than 36·5 degrees C. can be simply derived from cooling power H_1 at kata temperature of 36·5 degrees C. by equation.

$$H_2 = H_1 \frac{\theta_2}{\theta_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

where θ_2 is excess of temperature t_2 over that of the air and θ_1 is excess of 36·5 degrees over that of the air.

The effect of altitude or diminished barometric pressure is to diminish cooling power.

If H_1 = cooling power at pressure p_1

H_0 = cooling power at pressure p_0

$$H_1 = H_0 \left(\frac{1 + \sqrt{\dfrac{P_1}{P_0}}}{2} \right) \quad \ldots\ \ldots\ \ldots \quad (6)$$

or approximately the percentage change in cooling power is one-fourth the percentage change in pressure.

At the altitude of the Rand the pressure is about 20 per cent. lower than that of sea level, and the cooling power will be about 5 per cent. lower, other factors being equal. In the mines at the average working depths the change of cooling power may be neglected. This formula, of course, applies only to cooling powers calculated from atmospheric conditions of temperature, wind, etc., not to direct readings by the kata.

From equation (1) can be determined the cooling power in still air when the temperature is given, or inversely the temperature required for a given cooling power, and from (2) if the temperature and wind velocity are known, the cooling power can be calculated.

With the help of these equations let us now investigate the conditions in stope and level mentioned by Mr. D. Harrington, and find the dry cooling powers in definite units.

Temperature of stope 79° = 26·1°C.

$\therefore \theta_s = 36{\cdot}5° - 26{\cdot}1° = 10{\cdot}4$.

Temperature of level 82° = 27·7° $\theta_1 = 8{\cdot}8$.

V = 150ft. per min. = 0·762 metres per second.

$H_s = 0{\cdot}27 \times 10{\cdot}4 = 2{\cdot}81$ millicalories per sq. cm. per second.

$H_1 = (0{\cdot}27 + 0{\cdot}49\sqrt{0{\cdot}762})\ 8{\cdot}8$.

$= (0{\cdot}27 + 0{\cdot}43)\ 8{\cdot}8 = 0{\cdot}7 \times 8{\cdot}8$.

= 6·16 millicalories per sq. cm. per second.

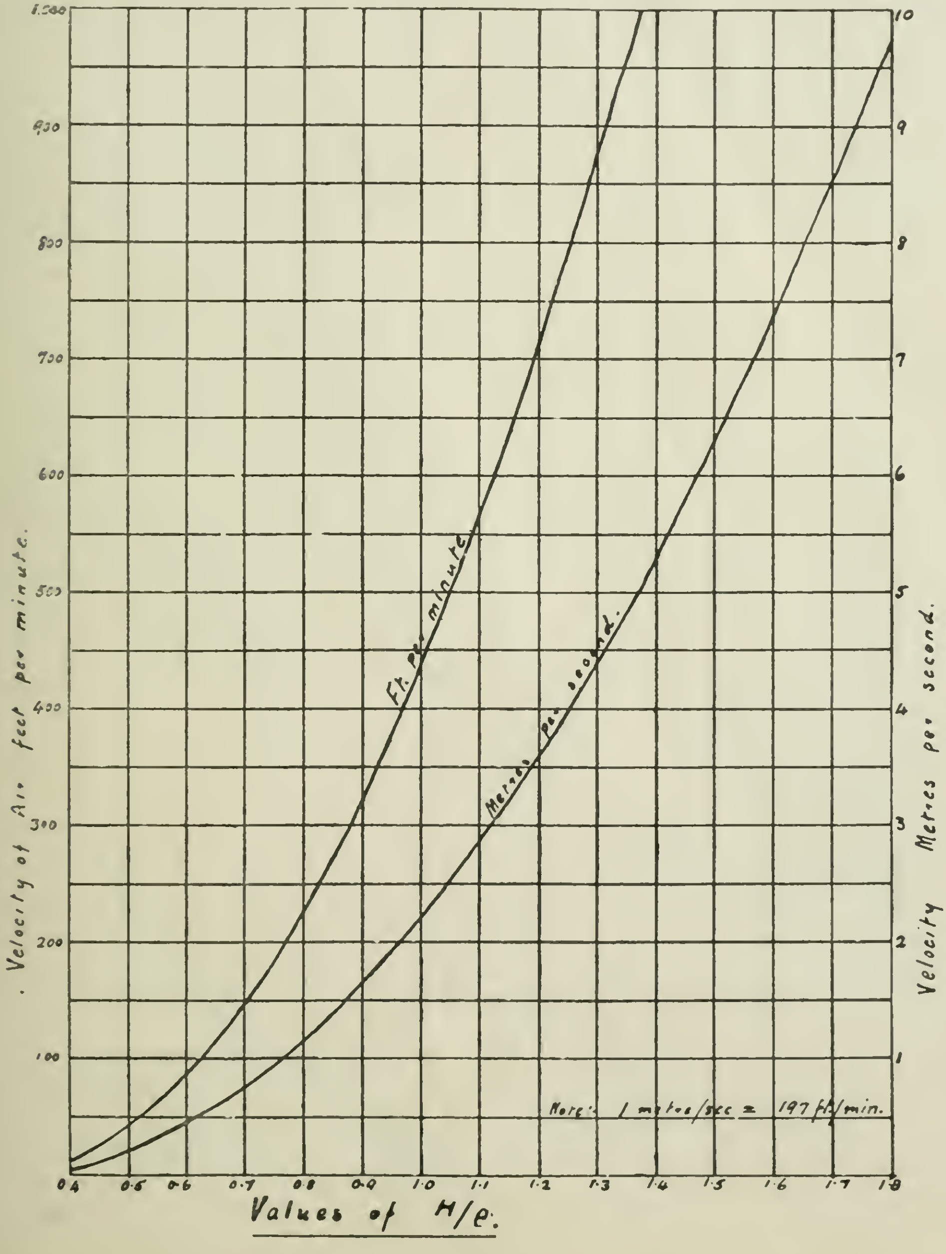
We can now realise better why the men climbed 100 feet to "cool off" as the cooling power of the level is more than double that of the stope, although the temperature of the former is 3 degrees F. hotter.

The cooling power of the level may be arrived at more readily by use of the curves in Fig. II. Take the velocity of 150 feet per minute. The corresponding value of H/θ is 0·7. Multiply this by 8·8 (the value of θ) and we get 6·16 as before. Fig. III. shows the velocities required to give dry kata cooling powers of 6, 8 and 10 at various tem

peratures. It will be noted how rapidly the values of velocity have to increase as the temperatures approach 25° to 30° C.

If the temperature and cooling power are known for air in motion, we can also from equation (2) calculate the air velocity in metres per second. The kata can thus be used as an anemometer in conjunction with an ordinary thermometer. The velocity in feet per minute (the usual British units) or in metres per second can be read off the curves in Fig. II. when H/θ has been determined. As an anemometer it has a fair degree of accuracy in currents with regular stream lines up to 25 metres per second (or approximately 5,000 feet per minute), but

FIG. II



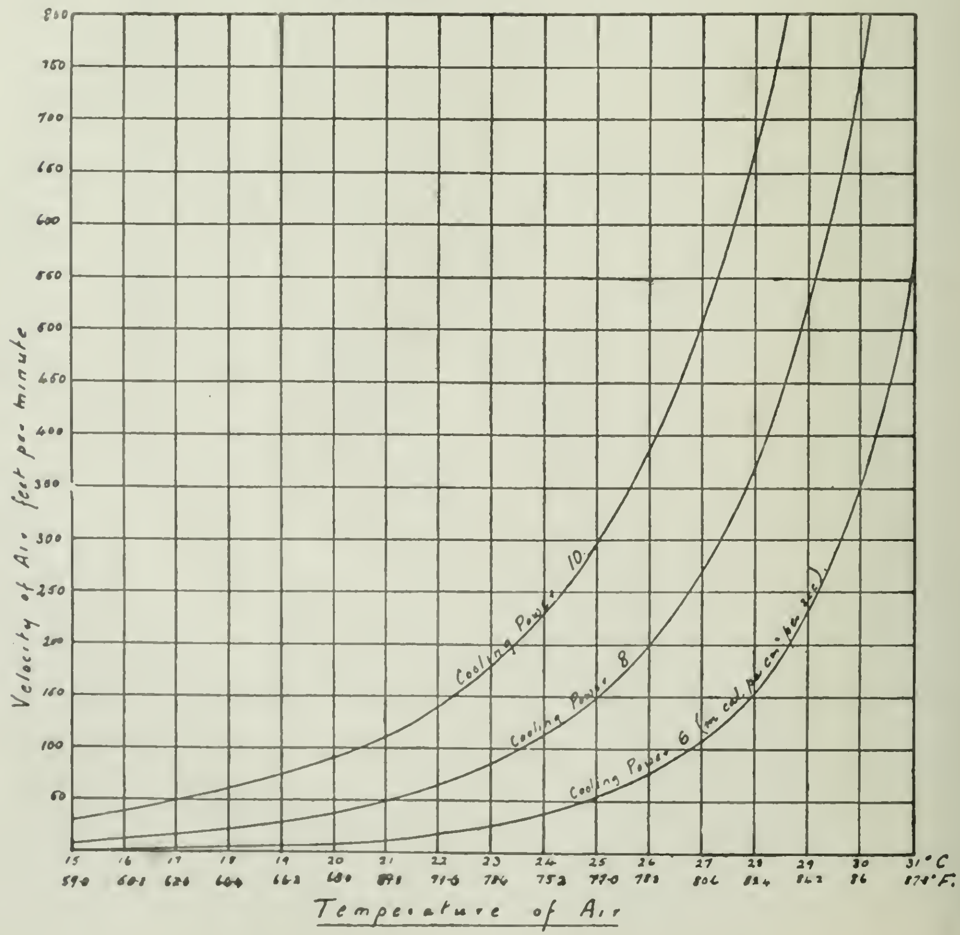
gives too high readings in currents which are turbulent and eddying.

I should say it was quite as reliable as the average windmill anemometer used in the mines, and is not liable to change of constant due to friction, etc., which is more than can be said for the windmill anemometer. It has the additional advantage of being sensitive to low velocity, while the pitot tube method, though very accurate, is not sensitive to air currents below 800 feet per minute, unless a very sensitive and delicate water gauge is used with it.

As the cooling power by dry kata (Hd) is the heat lost by radiation and convection, and that of wet kata (Hw) is loss by radiation convection and evaporation, the difference Hw − Hd = heat lost by evaporation, and thus from wet and dry kata readings the evaporative power of the atmosphere can be determined; this may be useful in finding evaporation from reservoirs, hot tanks, evaporative condensers, the value of Hd at the temperature of wet surface being found from equation (5), and of Hw by substituting for F in equation (3) or (4), the value of vapour tension at the temperature of wet surface; the difference between Hw and Hd will give the cooling power by evaporation and dividing this by the latent heat of water in the same units will give amount evaporated per sq. cm. per second. The water evaporated from the wet rock in the mines can be calculated in this way.

From equations (3) and (4) the vapour tension (f) of the atmosphere can no doubt be calculated from kata readings, but it is easier and more accurate to use wet and dry bulb temperature readings and a humidity chart or table. What can, however, be use-

FIG. III.



fully done is to calculate wet and dry cooling powers from records of temperature vapour tension and air velocity. I suggest that the kata and the equations established for it, might be used to investigate the possibilities of getting sufficient cooling power to carry on deep mining successfully, estimates being made of air temperature and practical values of air velocity ascertained from previous practice.

In conclusion, I would recommend those who are interested in this all-important subject to study "The Science of Ventilation,"* written by Professor Leonard Hill for the Medical Research Council, also to get a kata and take readings. They should take kata readings along with readings of wet and dry bulb temperatures, indoors, say, in the bedroom and dining room, and compare these with readings outside on the verandah; compare readings taken on a hot, dry day with those taken after a heavy rain; compare those of early morning with those of mid-day, those on an exposed height with those in the valley, and so on, and so on.

They will find it a never-ending source of interest, an interest well worth cultivating as it closely concerns the efficiency, health and well-being of the human race.

Dr. A. J. Orenstein (*Member of Council*): We have been taking a series of Kata readings for over three years along the Reef on the Village Main Reef, Village Deep, City Deep and other mines. We have found in practice that this is a very much better way of investigating actual atmospheric conditions in their relation to practical problems than anything which one could possibly obtain with the anemometer or thermometer. All this sounds very formidable; but the Kata is very easily used; anybody can learn to use it in a few minutes, and the calculations are very simple.

This paper may be considered as a short introduction to a paper which Mr. Ireland and myself hope to have the pleasure of submitting to you as the Associated Technical Societies on 12th February, when we shall have the first meeting of our Association.

Mr. H. Pirow (*Member*): I think the general interest in research work being taken all over the world to-day is also reflected in Mr. Ireland's paper as applied to mining here. One extremely important point mentioned in Mr. Ireland's paper is that of the amount of CO_2 permissible in mines. Although in some mines in Wales as much as 2% of CO_2 has been encountered and worked in underground, I do not think that this standard could be applied to the mines on the Rand, because naturally our conditions are different, the depths are greater, and we have greater saturation of water in the air.

I believe in France some time ago a standard of 75° Fahrenheit wet bulb was introduced as a practical limit for working in; it would be interesting to find out by means of the Kata thermometer what wet bulb temperature should be allowed under various conditions on our mines here.

Another interesting point Mr. Ireland brought out is that we have to rely on air movement to give relief to the worker underground, as the air is saturated with water; and this air movement, I think, is partly provided for by the Government regulation that there should be 30 cubic feet of fresh air per man per minute circulating. If this is properly carried out, I think we have quite a fair amount of movement of air in the average drive and "dead end."

Of special importance, in my opinion, are the advantages of the Kata thermometer over the anemometer for measuring air currents of low velocity. I think in practice all of us have found that the anemometer has its limitations, and very grave limitations at that; and the fact that the Kata thermometer can quite easily be applied to our ventilation problems underground makes it a most useful instrument. It should be of great advantage if it was, as Dr. Orenstein suggests, extensively used and tested on the surface and underground. I have great pleasure in moving a hearty vote of thanks to Mr. Ireland for his paper.

Mr. J. A. Woodburn (*Member of Council*): I wish to second the hearty vote of thanks to Mr. Ireland. This is quite a new instrument to mining men, and I have no doubt they will welcome it, and endeavour to become familiar with it, and compare its practical results in order to ascertain whether better conditions can be arrived at.

I am somewhat doubtful about agreeing with some of the remarks that have been made regarding the anemometer. My feeling seems to be that one of the reasons why the anemometer has not been so successful is that the velocity of the air is often so excessively low that the vanes are unable

* Published by H.M. Stationery Office, London.

to turn round. Now, the whole object we are trying to get at is to get the air to move at such a rate that it will turn the anemometer.

This Kata thermometer, being more delicate, will show us whether there is any movement or cooling effect in the air, but from some remarks in the paper I gathered that in eddying currents it was not quite so accurate, and might give too high readings. Now in dead ends and in awkward places to ventilate, there are almost certain to be eddying currents, and in connection with Mr. Laschinger's paper to which we have just listened, that was a point I was trying to emphasise. If one is taking the readings with the anemometer it is easily shown that the velocity in the centre of the drive is considerably greater than at the sides. In fact, in a fan drift where the velocity was very high, I have found the anemometer, in certain parts of the drift near the floor, to run backwards indicating a very strong eddying current. If such is the case where the air is flowing at a high velocity, it is much the same when it is floating around at a low velocity. I think we want far more readings and figures with regard to the motion of air underground than we have yet had, figures from actual practice, and not merely odd tests, and I am sure the anemometer can furnish such figures during working conditions, which will be greatly helpful in solving most of our ventilation problems.

CEMENTATION OF THE SUBSTRATA OF THE MAZOE DAM RETAINING WALL

By G. A. Voskule, M.A., Ph.D., B.Sc.

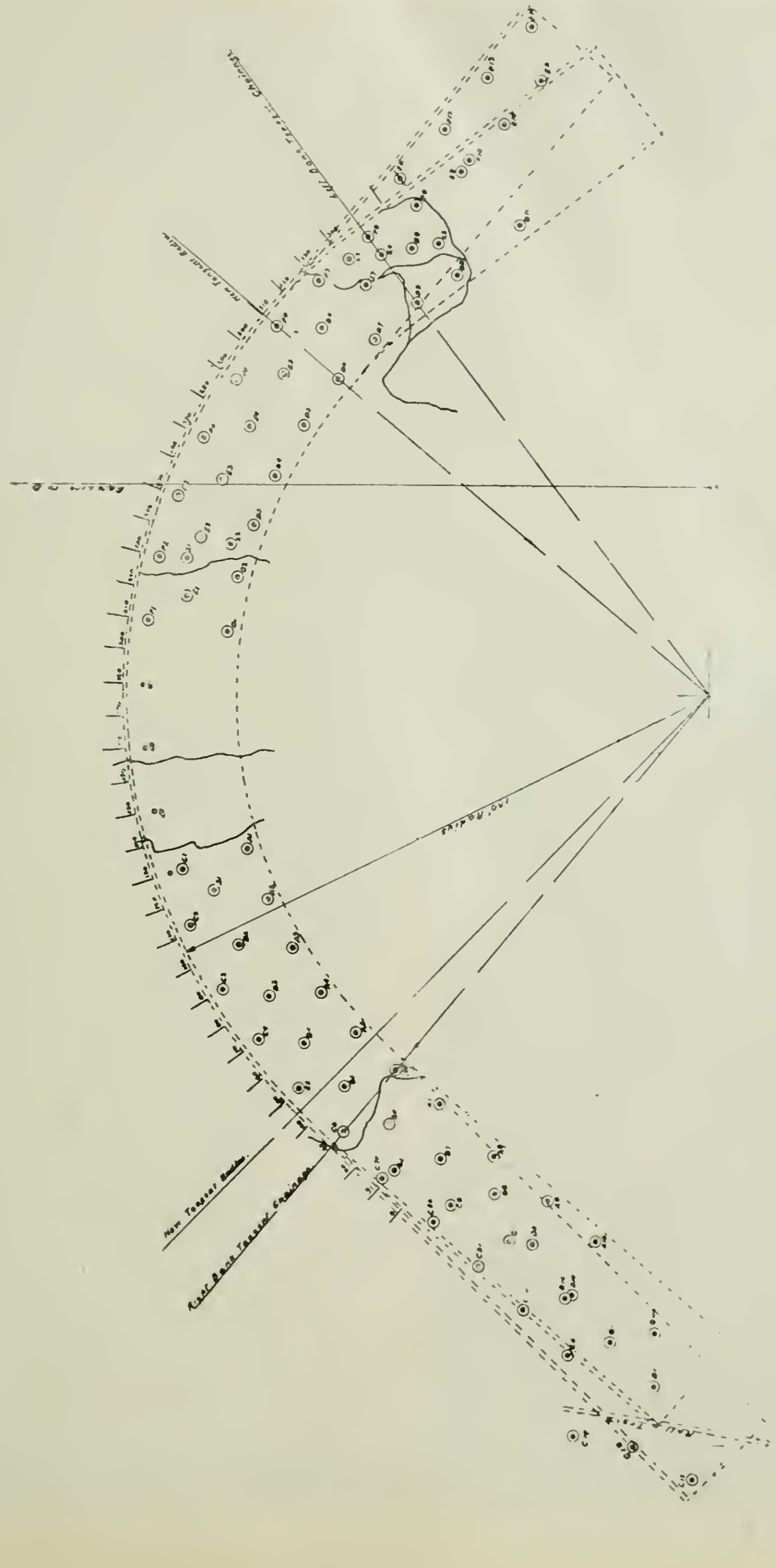
Dr. Voskule (*Visitor*): Before reading my paper, I wish to refer to a paper that was read before your Society here in 1918 by Mr. Krynauw, one of your members, describing the methods of cementation and its application. I will, in a few words, recall what was said on that occasion. By this process the cement is pumped into the ground as a very thin liquid to fill up all cracks, fissures and crevices—in other words, the ground is made solid and compact, one purpose being to prevent water passing through the ground where it has been made solid; other purposes are to make the ground strong enough to bear foundations, or solidify the foundations themselves. In the case we are going to consider to-night, it is to prevent water passing through the treated ground as well as strengthening the rock to bear the tremendous weight of the retaining wall. I have some specimens which I wish to submit to you, and will pass round now. Some show the rock before treatment, and others after treatment, you will notice the difference in solidity. They are labelled, which makes them self-explanatory.

Introduction.—At the monthly meeting of your Society on the 18th May, 1918, Mr. A. H. Krynauw,* then the technical manager of the François Cementation Syndicate in South Africa, read a paper entitled, "Cementation Process Applied to Mining" (François System). In describing the different applications of the process outside the field of mining, he mentioned: "Rendering impervious the foundations of surface dams or making solid the rock and concrete foundations of engines, buildings, etc."

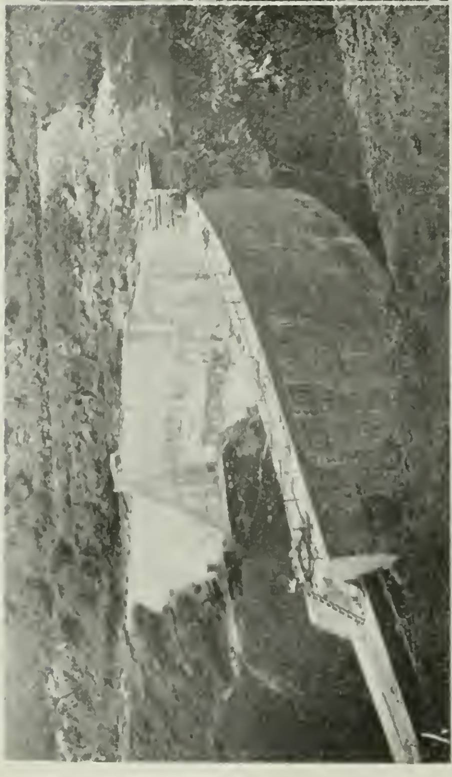
In the paragraph which amplifies this heading mention was made, that arrangements had been made betwen Mr. Albert François and the British South Africa Company for the application of the process in the construction of the dam for the Mazoe Irrigation Scheme in Southern Rhodesia. In this instance the cementation process was to be used for the purpose of solidifying and rendering impervious the substrata of the foundations to support the retaining wall of the dam, and thus save an enormous amount of excavation and subsequent refilling with concrete.

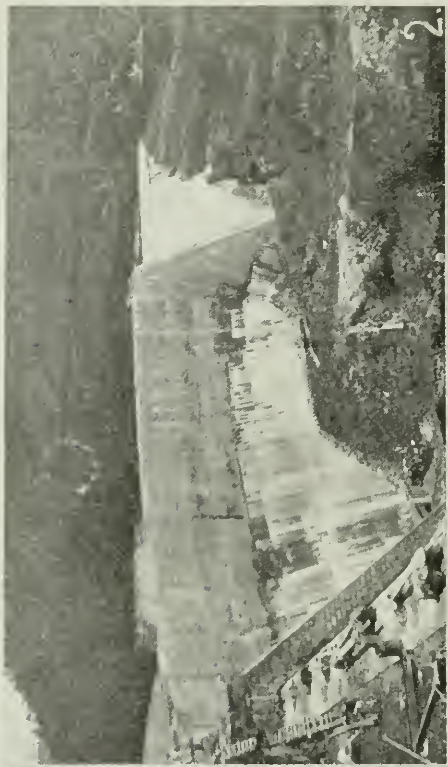
In due course the treatment of the ground to form the foundation of the dam by cementation was started, the treatment being completed on the 14th September, 1919, by which time the retaining wall had already reached a height of 75 feet. The construction of the dam and the cementation treatment were carried on simultaneously to this date, the dam itself being finally completed in March of this year.

* This *Journal*, Vol. XVIII., May, 1918.



MAZOE DAM.
CEMENTATION OF SUB-STRATA.





1.—Dam Retaining Wall.

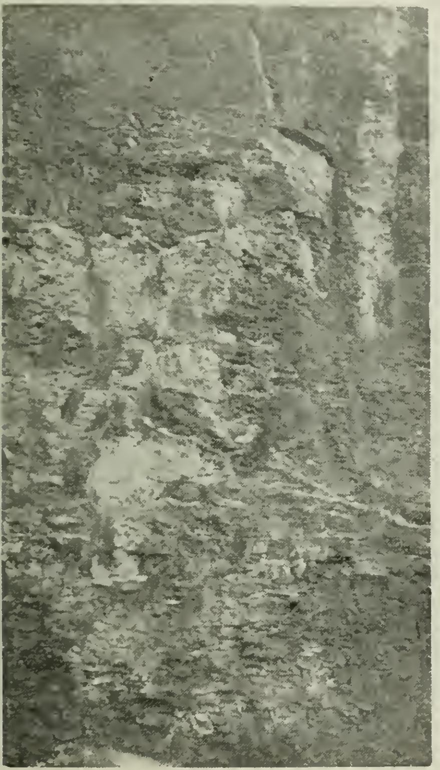
2.—Wall from North Spilway.

3.—Dam from North Spilway.

4.—Showing Leakage Outside Cemented Area.

The rock immediately underlying the foundations consists of oxidised ferruginous shales, with an average thickness below the foundations of 25 feet. The shales lie upon a base of acid igneous rock which, considered from the reservoir building point of view, may be considered impermeable and solid.

Due to oxidation and the accompanying stresses thereby generated, as well as subsequent earth movements resulting from igneous intrusions, also aqueous leaching



1
Showing Cement in Rock. Section Cut after Treatment.

causing the removal of the more soluble constituents, the shales are broken and interspersed with crevices, cracks and cavities, the latter extending in width up to 3 feet, as shown by the diamond drills, and in volume which was indicated by the amount of cement required for filling one of them, up to 900 cubic feet.

Weathering, generally speaking, left the rock soft and of a spongy nature making it not only porous, but also too weak and friable to bear any considerable weight

Calculated from the cement injected and the volume of rock treated, the cavity volume in the shales works out at approximately $\frac{3}{4}$ per cent. of the whole.

The acid intrusive rock upon which the shales lie, is an alaskite, and is locally known as dolerite. As you will see from the hand specimen, it is a compact crystalline rock, and in appearance not unlike our familiar "quartzite."

The thickness of shale where examined within the site area varies in thickness up to 100 feet. It underlies practically the whole area covered by the foundations and extends, increasing in thickness on each side

2
Showing Cemented Fissure.

of the dam, to form the range known as the Iron Mask Mountains. Many large eaves are exposed in the sides of the mountains, where the rock is not covered by denudation products, showing the easy weathering and leaching properties of the rock.

Situation.—The site of the dam is about 30 miles north of Salisbury, Rhodesia. The dam is put across the only gorge in the whole length of the range. Here the Mazoe River cuts through the range at right angles. The width of the gorge is about 60 feet at its narrowest, with sloping sides.

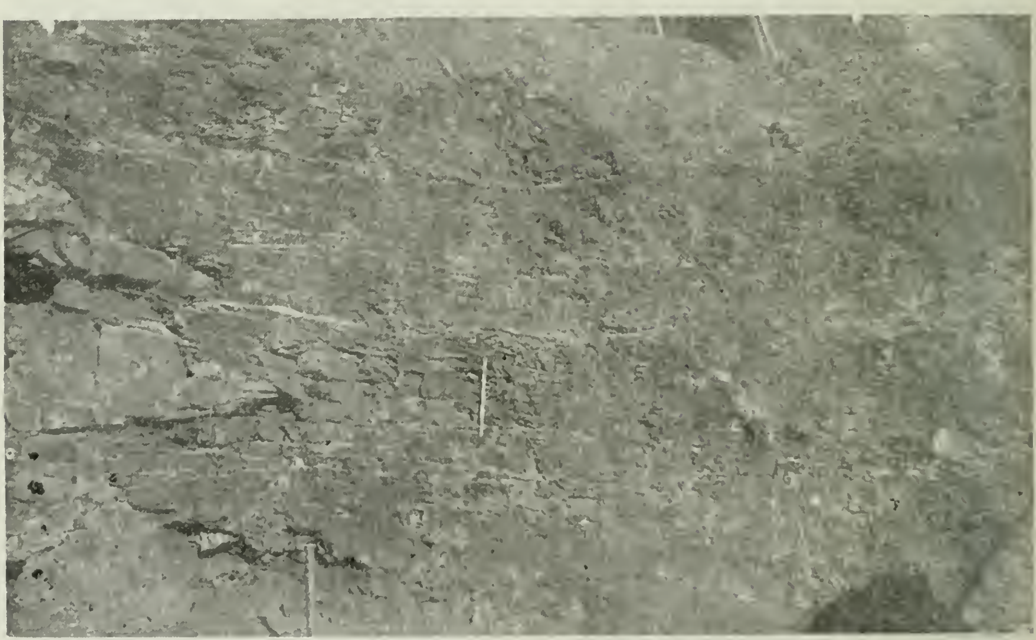
From quite a distance it is apparent that the gorge is an ideal spot for a dam. This view was entertained by many persons in previous years. Dam foundation sites had actually been pegged and marked at least twice previously. On closer examination, however, the schemes were abandoned owing to the weak and porous nature of the substrata. The amount of excavation and consequent cost in construction deterred private enterprise from attempting the work.

With the advent of the François cementation process the unsuitability of porous and weak strata without excavation for foundations became a trouble of the past, and the British South Africa Company was able to consider the gorge for a dam site in connection with a big irrigation scheme to irrigate the Mazoe Valley.

After preliminary prospecting work in the shape of shafts and crosscuts, it was found that the ground remained porous and weak to a considerable depth. Mr. Freeman, of Sir Douglas Fox and partners, the well-known London engineers, proposed the adoption of the François cementation process to evade the excavation which would otherwise be necessary. Mr. Albert François, who shortly afterwards came to South Africa, visited the site, and matters were fixed up for the cementation of the shales on which the foundations were to be built.

Application of the Process.—Drilling operations were commenced with an "H" Sullivan drill. The first hole struck igneous rock at 10 feet, but was drilled to 42 feet to test the igneous rock for cracks, etc. Up to this point the rock proved compact.

The original intention was to drill the holes in successive sections of 3 feet and inject each section separately. This was found impracticable owing to the time lost in each rigging, dismantling and moving of the diamond drill, which was further increased by the fact that all steam and water connections had to be made with rigid pipes, steam flexibles not being available.



3
SECTION CUT AFTER GROUND HAD BEEN TREATED.

It was decided to drill each hole to its total depth in one setting up. The depth being made up by penetrating the shales and about three feet into the underlying igneous rock in each case

The hole was filled with clay to within 3 feet of the top. The strata, to the depth of the empty portion of the hole, was then injected up to the required pressure. The

hole was then cleaned of cement and clay to 6 feet, or an extra length of 3 feet, when injection again took place, this time to a higher pressure rendered possible by the overlying cement reinforced layer. This procedure was repeated, clearing extra depths of 3 feet after each injection until the full depth of each hole was reached and injected, the average pressure being 400 lb. to the square inch.

The holes were placed along three concentric arcs of circles, following the shape of the wall to be, the holes in the middle arc being placed circumferentially midway between those of the other two arcs. Thus the holes were 14 feet apart. This is clearly seen from the accompanying plan. Eighty-two holes in all were put down.

If the small radius of 10 feet effective travel of cement in the rock be taken, the whole area is well covered. In actual practice it was found that the cement travelled up to 60 feet radial distance. In one case, the cement came out on a bench 30 feet above the top of the hole which was being injected, and on the same level as the hole the cement came out 65 feet away on the opposite side.

The work started on the river banks and progressed from the river outwards, so allowing a start to be made with the building of the wall as soon as possible.

The porosity of the ground proved to be very irregular, as had been expected. Thus we find a hole of 63 feet depth taking 3½ bags of cement to fill up all crevices, and another 33 feet, requiring 353 bags, before the same result had been obtained.

It was further found that occasionally one hole did the work of one or more others, *i.e.*, cement came out of one or more of the neighbouring holes, whilst injection was taking place at one point owing to their being inter-connected by fissures. The holes where leaking took place were plugged, and when the required pressure had been attained at the point of injection, the other holes where leakage had taken place were cleaned out, and it was found that on injection they took up immediately or very quickly showing that they had been partly or completely injected from the previous holes.

Diamond drilling on the whole was treacherous owing to the irregular laminar hardness of the shales. A total of 3,666 feet was drilled, at an average rate of 3 feet per working hour.

Results.—In considering the results it is well to remember that the cementation had to be done on theoretical lines. That is to say, no indications were available as to where the weakest parts of the rocks were except as shown in the course of the work by drilling. Also injections were carried on to certain pressures determined as the work progressed by the strain the rock wo[uld] bear without danger of fracture. Further, without making them unduly numerous, the holes were placed to enable the cement to travel into all fissures.

The efficiency testing of the ground only came when the dam began to fill. It is now apparent that the volume cemented is watertight, the ground outside of the treated ground being porous as before. A leak on the left bank, seen in the accompanying photograph, shows that the water goes round the cemented ground. This, of course, could now be treated and stopped, but it is the intention of the British South Africa Company engineers to leave it for one year before stopping it. This work will be done, and the work completed as soon as they give notice that they are ready for us to do so.

The following figures of quantities and costs are as supplied by the engineers of the British South Africa Company. Twenty-five thousand cubic yards of rock were treated by cementation at a cost of 8/- per cubic yard. The cost of one cubic yard of concrete laid down was 60/-.

It is evident that by the adoption of cementation a saving of 52/- per cubic yard was obtained, that is on the work as it stands —a saving of £65,000.

The actual cost of the wall itself, not including purchase of ground, head office charges, etc., was in round figures £62,000, making the actual structural cost, including cementation, equal to £72,000, instead of £127,000, which would have been the cost had not cementation been adopted.

The following is a table supplied by the resident engineer, showing details of cementation costs:—

COST OF CEMENTATION.

	Quantity.	Rate.	Amount.	To date.
1. CLEARING GROUND:—		£ s. d.	£ s. d.	£ s. d.
(a) Vegetation soil	2,220 cub. ft.	1 0	111 0 0	
(b) Covering ironstone for platforms	1,050 ,, ,,	3 0	157 10 0	
				268 10 0
2. DRILLING:—				
(a) Labour, fuel, oil, etc. "H" Drills	2,000 ft.	8 0	800 0 0	
(b) Beauty Drills	1,666 ,,	7 6	624 15 0	
(c) Rock Drills	60 ,,	5 0	15 0 0	
				1,439 15 0
3. CARBONS:—				
(a) "H" Drills	62 M. Carats	14 0 0	868 0 0	
(b) Beauty Drills	57 ,, ,,	16 10 0	940 0 0	
				1,808 0 0
4. CEMENT, @ 188 lbs.:—				
Per bag used	3,868 bags	18 0	3,481 14 0	
Pumping costs, power, etc. ...			1,099 16 0	
				4,581 10 0
5. PLANT—				
Purchase cost, transport and erection				
				1,700 0 0
6. FEES:—				
Travelling expenses, salaries, etc.				2,190 0 0
GROSS COST				11,987 15 0
Deduct realisable assets ...				1,987 15 0
				£10,000 0 0

Mr. E. M. Weston *(Member of Council):* I have much pleasure in proposing a vote of thanks to Dr. Voskule for his most interesting paper. As you know, this process has proved very economical under suitable conditions. If I remember rightly, in some of the large water schemes to supply Birmingham and some of the larger cities in Europe, they have had to excavate sometimes up to 100 feet or more of ground. This might have been avoided entirely by this process of cementation had they known of it. The damage done to the coal mines of Lens during the war period has been repaired by an intelligent application of this system, which has enabled the water from the upper water bearing strata to be shut off very rapidly. It will readily be realised that this process is of very great economic importance. No doubt more uses will be found for it as time goes on, and its scope in Africa will be very great. We have already heard of big schemes for barrages along the Orange and Vaal Rivers, and there are places in many other parts of Africa where the economic interests of the country will certainly call for it. I have been in Mazoe Valley, and the thing I chiefly remember in regard to it was the rich, red soil which is found along its banks in certain parts. This dam is only one of the examples of work which is going on all over Africa. I have been travelling a little over Africa lately, and have no doubt that when the mines of the Rand are exhausted and forgotten, it will preserve a civilisation for unknown ages. I think Dr. Voskule sufficiently explained all the details in regard to

the work; there is practically nothing to be said in regard to that. I think we are under a very great debt of gratitude for the very lucid description which he has given.

Mr. John Watson *(Member of Council)*: I have much pleasure in seconding this vote of thanks to Dr. Voskule.

THE IDEAL MINING LAW.

By C. J. Gray (*Member of Council*).

(*Printed in Journal, September, 1920.*)

Mr. J. P. du Toit *(Mining Commissioner, Johannesburg and Krugersdorp, Visitor)*: I thank you for your invitation to offer my observations on Mr. Gray's interesting and valuable paper. The author has used for illustration, where desirable, the Natal mining law. My remarks will be based upon my experience in the administration of the Transvaal gold law.

For easy reference my comments will follow the different sections of the paper *seriatim*, and as section 1 (judging from the concluding paragraph thereof) apparently refers to differentiation existing in the Natal Act, to which there is no parallel in the Transvaal Act, I will open with Section II.

II.—The provisions of the Natal Act to prevent the locking up of land against prospecting, as quoted by Mr. Gray, are a distinct improvement on the Transvaal Act, but do not to my mind go far enough in the attainment of the ideal. What I would advocate would be that a prospector should have the privilege to submit to the Mines Department his application to prospect *any* land under proper guarantees to compensate the owner for damage done to the surface of the land or otherwise. Thereupon notice should be served upon the owner calling upon him to commence prospecting operations on the land within a limited time, failing which a prospecting licence would be issued to the applicant in the first instance. To encourage a prospector, who accidentally discovers a mineral deposit on private land, to disclose his discovery, it may be provided that if, on information disclosed to him, the owner, in compliance with a notice calling upon him (owner) to prospect, proves a payable deposit, the prospector should be suitably rewarded by the grant of a definite interest in the discovery. The grant of a certain number of claims to the prospector would in rare cases only be a suitable reward, as the recognised owner's first choice would in most cases absorb the most valuable portion, if not the entire pay area. In any event, a defined interest in what the owner himself selects would seem to be the more just remuneration.

Mr. Gray rightly draws attention to the difficulties attending the imposition of labour conditions. I venture to suggest that those difficulties will be materially lessened, if labour conditions are confined to prospecting and development. My experience is that in this stage of the work the most reasonable provision is that work be done to the satisfaction of some responsible official, the penalty being a graduated increase in the licence money or fees, rather than confiscation of title. Once the mining venture has passed beyond the initial stages of prospecting and development, mining appears to be best encouraged by the imposition of taxation, subject to remission on a sliding scale according to work done.

What I would aim at is the setting of a level which will be the minimum of expense to the holder in fees and dues payable to the Treasury. That level would gradually rise if prospecting and development are not satisfactorily and continuously carried on, and would drop again as that work improves At the stage where actual mining commences I would immediately raise that level to a high point from where I would lower it by degrees as work proceeds, until it again reaches the minimum when mining has reached a certain point of efficiency.

III.—On part III., while I agree that discretionary power which might lead to forfeiture of rights, is unhealthy to the mining proposition which has reached the stage when considerable capital is required for development or equipment, I hold the opposite view during the period preceding that stage. While the mine is in a state of infancy it is very necessary that the conditions of title should be elastic, so as to permit of the utmost assistance to the holder. Such elasticity is best exercised, and perhaps only possible, through granting the officer charged with the supervision of those conditions wide discretion. In this respect, therefore, the ideal law would appear to be that which will lay down a dividing line between prospecting (including a certain amount of development) and mining. Perhaps the solution may be

to vest in some authority the power to decide this line in each individual case.

In the same section of his paper Mr. Gray refers to the difficulties experienced in accommodating the mine owner with surface rights. In gold mining in the Transvaal this difficulty is met by the disposal of the surface for mining purposes being vested by law in the State. During my eighteen years' experience of administration of the Gold Law I cannot recall a single instance where the reasonable requirements of the mine owner to the surface were not met. Yet it is worthy of consideration whether even this could not be improved upon by entirely eliminating the interests of the land owner, where mining has become successfully established, by, for instance, expropriation by the State of the land owner's interest.

IV.—Except for the suggestion which I made on the subject of rewards for discoveries when discussing Section II., I have no remarks to offer on this section.

V.—The procedure suggested by me in discussing Section II. of the paper for the purpose of overcoming the locking up of land against prospecting could, I think, be advantageously adopted where land is held under a licence for a particular class of metals to the exclusion of the working of the land for another and perhaps more valuable class, provided, of course, that the mining of the same piece of land for two different deposits of minerals is practicable, or, if impracticable, there is the means to decide to which class of mineral preference should be given.

For example, certain land is held by *A* under base metal licences. *B* satisfies the Mines Department that he is prepared to work the same land for precious metals within a specified time. *A* should then be called upon to work the land for precious metals within a certain time, failing which precious metal licences would be issued to *B*.

On the question of penalties, I would make such, wherever possible, attach to the title in the form of money payments collectable with the dues. If through accumulated penalties the dues become excessive, eventual forfeiture of title would not be too harsh a punishment.

VII.—In Section VII. the author discusses the relative advantages of centralisation and decentralisation of administration. Accepting Mr. Gray's views of the relative advantages and disadvantages, with which I fully agree, it becomes obvious, I think, that whereas decentralisation suits the prospector, the established mine is better served by centralisation. It does not appear to me impracticable to provide a dual system to meet both classes by centralising as much as possible the more responsible duties, and the administration of titles to established mines, in one office, with as many sub-offices as possible to deal direct with prospectors and possibly even small mining concerns in their early stages of development.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Detection of Arsenic in Sulphur.—" Schaeppi's method of detecting arsenic in sulphur (extraction with warm ammonia and treatment of the solution with silver nitrate to precipitate the dissolved sulphide) is untrustworthy, since sulphur itself dissolves in ammonia, and the resulting ammonium sulphide gives a precipitate of silver sulphide. The best method consists in oxidising the sulphur with bromine and nitric acid, and applying the Gutzeit test to the residue."—Harold S. Davis and Mary D. Davis, *J. Ind. Eng. Chem.*, 1920, *12*, 479 180.—*J.C.S.* Abstract, July, 1920. (H. R. A.)

Portable Apparatus for Estimating CO in Mine Air.—" According to *Nature*, Mr. J. I. Graham, research chemist at the Bentley Collieries, Doncaster, has devised a convenient portable apparatus for estimating small quantities of carbonic monoxide in mine air. It consists of a vessel containing a definite volume of the air sample. By operating a three-way tap and forcing water into the vessel the sample may be passed into iodine pentoxide in a U tube heated to go to 150° C. When examining air in the mine this temperature is maintained by hot oil in a thermos flask. The iodine liberated from the pentoxide is sublimed and driven into a tube containing a solution of potassium iodide in which the free iodine can be estimated by titration in the usual way. The inventor claims that a test can be completed in about five minutes with an accuracy of 0·005% using 100 cub. cm. of air or of 0·0005 per cent. with one litre. Mr. Graham has also devised a simple apparatus for determining the amount of oxygen in air by absorbing a definite volume of air in alkaline pyrogallol. Both descriptions of apparatus may be obtained from Messrs. Reynolds and Branson, 14, Commercial Street, Leeds.—*Iron and Coal Trades Review*, 6th August, 1920, p. 173. (J. A. W.)

The Physics and Chemistry of Colloides, Etc. —" The Faraday Society and the Physical Society of London are arranging to have a joint symposium and general discussion on this important subject

next October. The subject will be introduced by a brief survey of the present position of colloidal physics and chemistry, and discussion will then follow on the following subdivisions of the subject: Emulsions and Emulsification; Physical Properties of Elastic Gels; Cataphoresis and Electroendosmose; Precipitation in Disperse Systems; Glass and Pyrosols; Non-aqueous Systems. In spite of the importance of colloidal physics and chemistry in many branches of manufacture and of the interest which the subject has aroused in recent years, much light remains to be thrown on the nature of the manufacturing processes in which colloids play a part. It is hoped that the discussion will focus attention on some of these problems, and that its result will be to indicate lines of advance and suggest further researches, and that it will be fruitful not only in helping to a fuller understanding of the laws of the colloidal state, but also in suggesting new applicants for colloids in the laboratory and in the works. The exact date and place of meeting, and further particulars will be announced later. In the meantime anyone desirous of using the opportunity of the discussion to bring forward experimental matter or theoretical considerations bearing on the above-mentioned branches of the subject is asked to communicate as soon as possible with the secretary of the Joint Committee, Mr. F. S. Spiers, 10, Essex Street, London, W.C. 2."—*Ind. Engr.*, August 28th, 1920, p. 121. (F. W. W.)

Fused Quartz.—"Although attempts to produce fused quartz were made as early as 1839, its manufacture did not develop into an industry till about twelve years ago. The substance is now extensively employed in the manufacture of resistance thermometers, mercury thermometers with constant zero points, mercury vapour lamps, and lenses and prisms for optical instruments. Its chief properties are its insensitiveness to chemical influences, its low temperature co-efficient, its high melting point, and its great transparency. Bottomly and Paget in 1904 were the first to make large vessels of fused quartz. They found that when sand was melted in an electrically heated furnace a pasty mass was obtained which could be formed by the introduction of compressed air. It could be withdrawn from the furnace and blown out in iron moulds or drawn out without any additional heating. The product exhibited a snow-like outer layer, which could be ground away, the inner surface having a mother-of-pearl appearance. The opaque material could be made transparent by heating in an oxyhydrogen flame. It is now possible to manufacture quite large beakers, etc. of fused quartz. The substance begins to soften above 1,500° C., but in general it is not advisable to keep it, for a long time, above 1,200° C."—Anon, *Indian Eng.*, Sept. 25, 1920, p. 174. (J. A. W.)

METALLURGY

Discussion of Flotation at the Idaho School of Mines.—"The main conclusions of the discussion on grinding, led by W. L. Penick of the Hardinge Co., may be summarised as follows:—(1) Ball-mills have displaced practically every other form of crushing machine for final grinding, although it is possible that the disparity between them and chilean mills, stamp mills, and other machines would probably not be so great if the latter, instead of depending on screens for sizing, could be run on the overflow principle and in closer circuit with a classifier, as is done in standard ball mill practice. Cylindrical ball mills, however, require less space than any other form of crushing device.

(2) Stage reduction is still pre-eminent and likely to remain so as long as present devices are in use. Attempts to reduce 3in. material to 100-mesh product in one operation are inexpedient and wasteful. One inch feed for fairly soft ore grading to ¼in. for the hardest ore will yield the best results.

(3) Extremes of practice in ball mill grinding are represented by the Inspiration plant where 3in. material is reduced to pass 48-mesh at one operation, and by the mill of the Canada Copper Co., where crushers and rolls reduce the ore to 10-mesh, after which it is ground to 100-mesh by two-stage ball mill reduction.

(4) If some means could be found of eliminating the already sufficiently fine material from the return feed more effectively than is now done, much greater capacities could be obtained. This points to better classification in the ball mill circuit.

(5) The peripheral speed of ball mills should vary inversely as the fineness of grinding: 375 to 400 ft. per minute for 48-mesh product and 550 to 625 ft. per minute for coarse grinding, say, 8-mesh.

(6) Trunnion-overflow mills are, in general, superior to mills with grated discharge in capacity and character of product.

C. A. Wright of the U.S. Bureau of Mines discussed flotation testing. In addition to describing standard methods, he brought out the following points:—

(1) Flotation testing should be preceded by careful mineralogic examination of ores and in many cases by segregation of the various minerals in the ore and the assay and analysis of each segregate to determine the disposition of the various metal ingredients.

(2) Intelligent use of the microscope in examination of heading, concentrate, tailing, and intermediate products; also examination by the microscope of polished sections to show mineral association are vitally important. The application of this work to certain zinc-lead ores of the Cœur d'Alene has shown that in 200-mesh particles magnified to 1in. diam. there are particles of galena the apparent size of wheat grains imbedded in solid sphalerite and at times similar areas of sphalerite surrounded by galena. It is evident of course that nothing short of molecular dissociation can separate zinc and lead in such ores.

(3) Wet crushing preliminary to testing for flotation has generally yielded results from 5 to 10 per cent. higher than is yielded by the same treatment applied to ore samples crushed dry.

(4) Satisfactory differential flotation of zinc-lead ores of the Cœur d'Alene can be made, provided the ores are not of the character discussed in paragraph 2. Such separations show recoveries of 80 per cent., with lead products assaying 60 per cent. lead and 6 to 8 per cent. zinc; and zinc products containing 40 to 45 per cent. zinc and 5 to 6 per cent. lead. Mixtures of No. 2 or No. 4 Barrett oils with coal-tar creosote in sodium silicate or carbonate solution generally give good results.

(5) Results secured under laboratory conditions may not be duplicated under mill conditions owing

to difference in character of feed, elimination of certain substances, or inclusion of certain other substances during the milling process. The use mill-water may give different results to those obtained by employing clean hydrant water.

R. B. Elder showed in the laboratories the possibility of arranging various oils in the order of their interfacial tension with water. The first oil in the series was dropped on water and spread into a film, this film being in turn displaced by a film made from a drop of an oil of lower interfacial tension, and so on down the series. It is evident that if the same principle could be applied to the attachment of oil films to minerals, and if a definite series of 'affinities' could be worked out, we would have made some further progress along the path of differential flotation.

An effort was made to enumerate important phases of flotation concerning which information is lacking. The following were agreed upon as needing further investigation:

(1) Maximum and minimum size of particles recoverable by flotation.

(2) Relation between size of bubbles and size of particle.

(3) Relative floatability of the members of the series galena, chalcopyrite, sphalerite, pyrite, and pyrrhotite.

(4) Influence of depth of column on effectiveness of the bubbles in collecting mineral.

(5) Affinity or adhesion between various minerals and different oils.

Is classification desirable preliminary to flotation?

J. Benjamin Parker, metallurgist for the Interstate-Callahan Company, in an informal address, stated that shortly before returning to the Cœur d'Alene he had had considerable success with the use of SO_2 gas in selective flotation on a small scale. The gas immediately renders the blende non-floatable, thus permitting the floating of galena in presence of sphalerite. There is some question whether the SO_2 is best added intermittently in thickeners or other storage tanks, or whether it can be used to better advantage in the flotation cell itself. An interesting point was made by Mr. Parker on the effect in the Interstate-Callahan mill of burning sulphur in the vicinity of the zinc-flotation machine, the zinc froth being 'killed' entirely for a considerable period, to the great mystification of the mill operators.

M. H. Sullivan, metallurgist of the Bunker Hill smelter, discussed the difficulties introduced in lead-smelting practice by the necessity for handling flotation concentrate. The main objections from the smelter's point of view are as follows:—

(1) Difficulty in unloading from cars when received at the smelter, much of the material being sticky and clinging to shovels, the wheelbarrows, bin walls, and chute gates, and being almost impossible to sample. In certain cases men practically refuse to handle some of the material sent in.

(2) Mechanical handling of the stuff on belt-conveyors, belt feeders, spouts, and the like is in many cases impossible.

(3) Extreme difficulty in getting a uniformly roasted product from the Dwight & Lloyd machines. Lumps and unroasted masses are produced, thus leading to excessive matte-production and development of furnace-accretions, unless re-crushed and re-roasted.

(4) Extra fuel consumption required to dry the material.

The remedies for these conditions would appear to lie in more careful elimination of moisture at the mills either by American filters, which were reported to be doing good work at the Hayes mill below Kellogg, or in Oliver filters, which many mills are using. The Lowden dryer is also being used at the Hayes mill with fair success. A new type of dryer devised by Elmer Brain, who is operating a tailing mill at Kellogg, was reported to be giving good results. The obvious disadvantage of paying freight on water makes evident the need of drying. From 5 to 7 per cent. was stated to be the desirable moisture content in flotation concentrate to be sent to roasters of the D. & L. type. The mixing of flotation and gravity concentrate would appear to be desirable. Unless flotation operators show a little more consideration for the smelters a penalty will have to be placed on flotation concentrate carrying excessive moisture.—*Mining and Scientific Press*, 27th Mar., 1920, p. 459. (H.A.W.)

Hydro-Metallurgy of Zinc.—Zinc sulphide resists most ordinary solvents, not being dissolved with sufficient rapidity by any of the commercial acids, hence requires roasting before the majority of the proposed hydro-metallurgical processes can be applied. Sulphide of zinc is one of the most refractory sulphides to roast, on that account the cost of zinc roasting is higher than that for any other major metal. In order to get the zinc into solution after roasting, it may be converted into a sulphate or a sulphide, or hydrochloric acid may be used as a solvent for the leaching of zinc sulphide ores in localities having industrial plants where acid is a useless by-product. Hydro-fluosilicic acid is also recommended [it is used at Trail, B. C.] as being a desirable solvent for roasted zinc ores, on account of the ease of precipitating zinc from solutions by electrolytic methods.—D. A. Lyon and O. C. Ralston, in *Mining and Scientific Press*, July 12, 1919, p. 54. (H.R.A.)

MINING.

Atmospheric Conditions at the Morro Velho Mine, Brazil.—With regard to the ventilating arrangements of the Morro Velho mine owned by the St. John del Rey Mining Company, Limited, and situated in the State of Minas, Brazil, which is at present the deepest in the world, the lowest working being 6,400 ft. below the surface, and 3,650 below sea level, the underground atmospheric conditions, as they might imagine, were very severe. Luckily for them, the rate of increase of rock temperature with depth was considerably less than that indicated as being usual. Whereas the latter was 1 deg. Fahr. for every 70 ft., theirs was only 1 deg. for every 140 ft., although there were indications that the rate was increasing slowly for increased depth, so that for the lowest 2,100 ft. the rate was about 1 deg for every 119 ft. In 1913 he was entrusted with an investigation into this matter with a view to overcoming the difficulties and rendering the mine workable at depths considerably greater than those which had been reached. The only instruments he had were an aneroid barometer and wet-bulb and dry-bulb thermometers. Readings were taken at every level right down through the mine, and the results were plotted on diagrams

having depth in feet for base. It was found that the dry-bulb temperature at one point in the mine remained practically constant all the year round, but that the wet-bulb temperature underwent considerable variations. For the same dry-bulb temperature and barometic pressure the wet-bulb temperature depended on the moisture content, and the tests he took showed that—the conditions being equal, and as might have been expected, the mine being a dry one—the moisture content at any point underground (and therefore the wet-bulb temperature at that point) depended almost entirely on the moisture content of the surface air entering the downcast shaft. The whole question, therefore, was to find by analogy from the diagrams that volume of the entrance moisture contents which would give wet-bulb tempertures in the working zone below what had been fixed upon as the limiting value—corresponding to the 80 deg. Fahr., mentioned in the Report. Then the temperature at which the air when saturated with moisture would have this required initial moisture content was that to which the downcast air would have to be reduced before it entered the mine. By hourly hygrometric observation at the surface, extending over a whole year, the worst conditions likely to be reached by the surface air were approximately known. Hence, knowing the volume to be dealt with, the amount of refrigeration necessary, power required, and so on, could be calculated. In their own case it was found from the diagram that in order that the wet-bulb, temperature in the stopes should not exceed 82 deg., which they had fixed upon as a maximum desirable, the initial moisture content must not be more than about 50 grains per pound of dry air, corresponding to a saturated condition at 45·5 deg. Fahr. The plant, which was now being erected, was capable of eliminating about 100,000 B.T.U. per minute. This corresponded to the cooling of the volume of air, 80,000 cub. ft. per minute from an initial wet-bulb temperature of 72 deg. (slightly below the maximum actual condition) to 43·5 deg., so that it was on the safe side. As the surface wet-bulb temperatures varied during the year between 75 deg. and freezing point (32 deg.), it would be understood that the refrigerating load on the plant would be a very variable one. To meet those conditions they were dividing the plant into six stages, each complete with its own motor-driven ammonia compressor, condenser, and evaporator. The number of those sets running at one time would of course depend on the initial temperature conditions. The air-cooling would be accomplished indirectly, as it would be deadly to have ammonia mixed with the entering air. Therefore the ammonia would be used to cool water which in its turn would cool the air as it passed through by Heenan air coolers.—E. Davis, *Iron and Coal Trades' Review*, Sept. 12, 1919, p. 322. (J. A. W.)

Abstract of Patent Applications.

692/19. Woodworth, Tregaskis and others. Improvements in magnetic separators. 26.8.19.

This application relates to magnetic separators for ore and other substances or material. The claims are ten in number, and are as follows :—

1. In a magnetic separator, the provision of an auxiliary pole (as 11) substantially as and for the purpose described.

2. A magnetic separator according to the preceding claim, in which the auxiliary pole is provided with an energising coil (as 66) substantially as and for the purpose described.

3. A magnetic separator as claimed in either of the preceding claims, in which the auxiliary pole is adjustable independently of the pole with which it is connected, substantially as and for the purpose described.

4. A magnetic separator according to Claim 1, in which the main pole system provides two zones and the auxiliary pole a third zone, which latter is available for the separation of magnetic substances of varying permeabilities, substantially as described in connection with the accompanying drawings.

5. In a magnetic separator, the provision of supplementary adjusting means for the main pole or poles, substantially as described.

6. A magnetic separator according to Claim 5, in which the said adjusting means consist of distance pieces or plates of suitable thickness or proportions, substantially as described.

7. In a magnetic separator providing the guards, for the edges of the pole pieces with extensions or their equivalent for carrying the guide pulleys for the cross belt or belts, substantially as described.

8. In a magnetic separator according to any of the preceding claims, the provision of a device or tapper (as 63) intermediate the poles, substantially as and for the purpose described.

9. In a magnetic separator, according to any of the preceding claims, the driving means which is characterised by the employment of straight as opposed to cross belts, substantially as described in connection with the accompanying drawings.

10. A magnetic ore separator constructed and arranged to operate substantially as hereinbefore described in connection with the accompanying drawings.

760/19. T. J. Armstrong (S.A.), Ltd. Improvements in apparatus for manufacturing reinforced and other concrete pipes, columns and the like 18.9.19.

This application refers to an apparatus or machine for manufacturing concrete and similar pipes and the like, comprising a stationary mould and means of rotating within said mould, said means operating to impel or throw the concrete or like material against the wall of the stationary mould and to impart the requisite internal shape to the pipe or the like, substantially as described.

975/19, 976/19, 977/19, 978/19. Messrs Vickers, Ltd. 27.11.19.

All these applications refer to improvements in or relating to systems for driving machinery subject to fluctuating loads.

1091/19. Continuous Centrifugal Separators, Ltd. Improvements in continuous centrifugal decanters. 24.12.19.

This application is for a further development of the Mauss centrifugal machines, in which the drum consists of a number of separating chambers with conical walls, capable of being periodically parted for discharge of solids. Provision is made for continuous discharge of clarified liquid, and an observation launder is provided to enable the periods of discharge to be determined.

123/20. W. R. Hume. Improvements in or relating to the moulding of concrete products. 12.2.20.

This specification relates to improvements in or relating to the moulding of concrete products.

140/20. W. J. W. Strong. Temperature indicating apparatus. 19.2.20.

The object of this application is an instrument for measuring the temperature due to the expansion of a chain of linked strips of metal actuating on a lever, to which is attached a pointer with a dial similar to an ordinary pressure gauge.

209/20. Société Belge d'Outillage Pneumatique (Ateliers Rorive), Société Anonyme. Automatic stopping device for pneumatic pike-hammers and other pneumatic tools. 11.3.20.

The applicant states that the subject of the present application is an improvement on No. 353/19, and has for its object the provision of improved automatic stopping means actuated by compressed air for pneumatic tools.

According to this application, the cylinder of a pneumatic hammer is fitted with a sliding liner which extends the full length of the cylinder, and at the front end makes contact with a collar on the tool. Internal port-openings are so arranged that there is a constant tendency for the air pressure (when the air is turned on) to force the liner out of the cylinder so that the end of the liner projects a limited distance from the front of the cylinder.

The valve is of the cylindrical type originally introduced by Boyer, and operates outside the liner; suitably arranged ports in the latter communicate with the valve.

The ports in the liner are so arranged that when the liner is pressed out, communication with the valve is cut off; but when, through the tool being pressed against the work, the collar on the tool pushes the liner back to its rear position in the cylinder, communication is retored with the valve through the ports in the liner. In this way pressing the tool up to its work at the same time opens its supply of air, and removing pressure from the tool cuts off its supply of air.

332/20. Messrs. William Russell and Minerals Separation, Limited. Improvements in and relating to coal-washing and the apparatus therefor. 8.4.20.

This specification describes the treatment of fine Duff coal mixed with shale in a washing machine where it is violently agitated. A small quantity of mineral, animal, or vegetable frothing agent being added during the agitation (from 1 to 5 lbs. per ton of frothing agent to 1 ton of coal handled) for the recovery of clean coal from the mixture of Duff and shale and pyrites.

471/20. W. A. Curless Co. (Inc.). Concrete pipe machine. 18.5.20.

This application refers to a machine for making concrete pipes, comprising a rotating mould, a relatively fixed core and a tamping bar mounted on a swinging-head on a stationary post, the said head being adjustable in a position at right angles to the rotation of the mould and reciprocated in guide sockets carried on and adjustable with the swinging-head, substantially as and for the purpose set forth.

665/20. J. Miller. Improvements in and relating to filters. 2.7.20.

This application relates to improvements in pressure filters, and consists of a chamber mounted on hollow trunions.

The liquor to be filtered passes into the chamber through one trunion, thence through the filtering medium and out through the other trunion.

The filtering medium suggested is megass or similar material which is fed into the chamber through an opening at one end and then subjected to pressure by a simple mechanical contrivance operated by means of a hand wheel outside the cover.

Seymour Memorial Library.

The following books have recently been added to the Library :—

"The Mines Handbook and Copper Handbook (1920)," W. H. Weed.
"Manual of Petrographic Methods," A. Johannsen.
"Metallurgical Calculations," J. W. Richards.
"Igneous Rocks and their Origin," R. A. Daly.
"Catalysis in Theory and Practice," E. K. Rideal and H. S. Taylor.
"Manganese Ores," A. H. Curtis.
"Tin Ores," R. H. Rastall and W. H. Wilcockson.
"Industrial Gases (1920)," H. C. Greenwood.
"Explosives," E. de Barry Barnett.
"Machine Tool Operation," H. D. Burchardt.
"Reinforced Concrete in Practice," A. A. H. Scott.
"Cement," B. Blount.
"Asphalts and Allied Substances," H. Abraham.
"Forging of Iron and Steel," W. A. Richards.
"The Thermionic Valve in Radiotelegraphy and Telephony," J. A. Fleming.
"Refrigeration," M. W. Arrowood.
"Practical Electric Welding," H. B. Swift.
"Electro Plating," A. Watt.
"Lathes: Their Construction and Operation," G. W. Burley.
"Lathe Work (1918)," P. N. Hasluck.
"Tube Milling," A. Del Mar.
"Basoline and Kerosene Carburettors," V. W. Fage.
"Compressed Air Plant (1919)," R. Peele.
"Sheet Metal Workers' Manual," L. Broemel.
"Oils, Fats and Waxes," G. Martin.
"The Ownership and Valuation of Mineral Property," R. A. S. Redmayne and G. Stone.
"The Production and Treatment of Vegetable Oils," T. W. Chalmers.

Changes of Address.

Clevenger, G. H., *l/o* New York; c/o United States Smelting, Refining and Mining Company, 55, Congress Street, Boston, Mass.

Gepp, H. W., *l/o* Hobert; Box 856, G.P.O., Melbourne, Australia.

Kelly, A., *l/o* Crown Mines; New Modder G.M. Co., Ltd., Box 25, Benoni.

Sorenssen, S. S., *l/o* Rancagua; Braden Copper Co., 120, Broadway, New York, U.S.A.

Spoor, A. L., *l/o* Box 668, Johannesburg; P.O. Box 7312, Johannesburg.

Steels, S. H., *l/o* Village Main Reef G.M. Co., Ltd.; Geldenhuis Deep, Ltd., Box 54, Cleveland.

Wells, E. F. V., *l/o* Village Deep, Ltd.; Tweefontein Colliery, P.O. Minnaar, Transvaal.

Wilkes, H. R. S., *l/o* City and Suburban G.M. and Estate Co., Ltd.; 284, Commissioner Street, Johannesburg.

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CHEMICAL METHODS OF DE-AERATION OF WATER OR SOLUTIONS.

By H. A. White (*Member of Council.*)

The amount of dissolved oxygen met with in cyanide solutions or in boiler-water feeds may vary from 1 to 10 mgm. per litre, and in the following figures 6 mgm. per litre is assumed to be present, and the necessary correction must be made in any other case. This 6 mgm. per litre is equivalent to:—0·0006% or 6 parts per million, or alternatively 0·012 lb. per ton of 2,000 lb.

The total gas dissolved in alkaline solutions will be about 2% by volume at N.T.P., and this would represent about 40% of the volume of the solution at an absolute pressure of 1/20 of an atmosphere.

I am not aware that at present any industrial methods are largely used for removing dissolved oxygen from solutions, though such would possibly be profitable in the case of certain operations in the tanning of leather and in the use of "vat" dyes. Nevertheless the operation of chemical reduction is one frequently employed in industry, and where fluids are concerned the chief agents employed are principally nascent hydrogen, ferrous salts, sulphites, hyposulphites (sometimes known as hydrosulphites) and thiosulphates.

For the purpose of removing oxygen from cyanide solutions before gold-precipitation, or from boiler-feed water, the ideal chemical compound should fulfil the following conditions:—

(1) Low price and easy supply.
(2) Insolubility after oxygen absorption.
(3) Freedom from other undesired reactions.
(4) Rapidity of reaction with oxygen.
(5) Large capacity for oxygen absorption.

With reference to (1) it is obvious that a reagent which must remove 0·012 lb. of oxygen for a small fraction of a penny per ton will have to be a chemical which is quoted at a price per ton, and not one like pyrogallol and other photographic developers which are quoted at a price of shillings per ounce, though such substances answer well requirements (4) and (5).

(2) Insolubility after the reaction would rule out hyposulphites which are sold under various trade names for use in the dye industry, even if the cost for our present purpose were not out of the question: they are, however, readily prepared from the cheap materials, zinc and sulphur dioxide.

(3) Ferrous sulphate cannot be used in presence of cyanides even in dilute solution as is demonstrated by experiments detailed later on, owing to the well-known formation of ferrocyanide and consequent destruction of cyanide.

(4) Sulphites and thiosulphates do not react with dissolved oxygen with anything like the required rapidity, and in the case of the latter there is also an undesired (though very slow) reaction with cyanide to form thiocyanates. Sulphides are similarly ruled out, for, though the action is more rapid, yet the first product of the reaction is thiosulphate as above.

As sulphite and thiosulphate are actually present in small quantities in cyanide solutions which are at the same time nearly saturated with oxygen a further investigation was dispensed with. The only substances so far investigated as likely to be of value in the required directions are ferrous sulphate, manganese sulphate and tannin.

Experimental.—Four Winchester quart bottles were simultaneously filled with solution entering slime boxes, and the stoppers inserted without air bubbles. Three were taken for the purpose of adding tannin, ferrous ammonium sulphate, and manganese sulphate respectively, and the fourth was for preliminary analysis. The stoppers were withdrawn for the addition of each chemical in solid form, and were then at once replaced without inclusion of air bubbles. After thorough shaking till solution was complete, the bottles were left standing 23 hours for settlement of the precipitates. Thereon a portion was siphoned off carefully into 300 cc. bottles for oxygen determination, and the remainder of the solution was filtered off for the rest of the analysis. Temperature was taken before and after completion of the tests. The aim in each case was to have a slight amount of oxygen left after completion of reaction so that an estimate of the efficiency of the chemical used could be made.

Results.—

Initial conditions and analysis.
Temperature, 18 C.
Oxygen, 5·5 mgm. per litre.

KCN (free)	0·009%.
KCN (total)	0·010%.
NaHO	0·0140%.
$Na_2S_2O_3$	0·011%.
Na_2SO_3	trace.*
KCNS	0·004%.
K_4FeCy6	Nil.

(A) *Tannin.*—(As a pure *commercial* product was used the old formula is retained instead of Fischer's glucoside formula).

Probable reaction.

$$C_{14}H_{10}O_9 + 2CaO + O_2 = C_{14}H_4O_6Ca.CaO + 3H_2O.$$

322·08	: 160·04 †	: 32.	
10·065	: 5·001	: 1·000.	
60·39	: 30·00	: 6·00	mgm. per litre.
0·006%	: 0·0030	: 0·0006	per cent.
0·121	: 0·060	: 0·012	lbs. per ton of 2,000 lb.

A blue-green precipitate first formed changed slowly to light greenish yellow, and settled very slowly, so that a perfectly clear solution was not obtained even after 23 hours. The precipitate was soluble in acetic acid, and was apparently reduced again by zinc shaving, the colour changing from deep brown to colourless, and the resulting solution giving characteristic reactions with ferric chloride and with ammonium ferricyanide.

The filtered solution showed no reaction for tannin with ammonium ferricyanide and ammonia, though this was shown to be sensitive to one part in 200,000. This is important, as tannin was shown to cause plating of lead on zinc shaving in place of the usual feathery deposit necessary for good gold precipitation.

Final conditions and analysis after 23 hours.
Temperature, 8 C.
Oxygen, 0·5 mgm. per litre—loss 5·0 mgm. per litre.
Oxygen after shaking vigorously with air, 7·0 mgm. per litre.

KCN (free)	0·009%—no change.
KCN (total)	0·010%—no change.
NaHO	0·0104%—loss 0·0036%.
$Na_2S_2O_3$	0·012%—no change.
Na_2SO_3	Nil—no change.
KCNS	0·004%—no change.
K_4FeCy6	Nil—no change.

The capacity of the bottle was 2,775 cc. and 0·130 gm. of tannin was taken. The oxygen removed was 13·88 mgm., while the tannin according to equation above was equivalent to 12·92 mgm. Oxygen therefore requires just 10 times its weight of pure tannin for complete removal, and the difference between theory and practice is not noticeable.

The loss in alkalinity 0·0036% compares favourably with the theoretical 0·0030%, and a duplicate experiment without filtration showed loss of 0·0032%, so that theory and practice are again very close indeed. The loss of lime, amounting to 0·044 lb. per ton of solution, is less than in the other experiments and is not a serious matter.

As wattle-bark contains up to 35% of tannin, and the extract is made in this country, the possibility of its use appears to be a matter of price, which must not exceed 2d. per lb.

(B) *Ferrous Ammonium Sulphate.*—A similar experiment using ¾ gram of this substance gave the result that, although the oxygen was practically all removed, yet half the cyanide was destroyed. About 4/5 of the ferrocyanide formed was in solution, and the rest as prussian blue. Therefore about 82% of the iron salt was used against oxygen and 18% wasted on the expensive side reaction, which involved a loss of cyanide to the value of more than one penny per ton of solution. The loss of alkalinity was somewhat greater than the theoretical, but the solution was filtered, and no doubt the precipitate absorbed a small amount. The

* To Bödeker's reaction.
† 2 NaOH for CaO.

above experiment is placed on record to make it perfectly clear that ferrous salts cannot be used in practice for removing oxygen from cyanide solutions, however obvious the notion may seem in theory. In the case of boiler feed water, however, the cost would amount to about 0·4 d. per ton if ferrous sulphate were made from scrap iron and common sulphuric acid; filtration in covered tanks would probably be necessary, though if tannin were used instead, even settlement would be superfluous in view of the advantage of having colloids present to hinder scale formation.

(C) *Manganese Sulphate.*

Probable reaction.

$$MnSO_4 + 4H_2O + CaO + O = CaSO_4 + MnO_2 + 4H_2O.$$

223·06	56·07	: 16·00.
13·94	: 3·503	: 1·00.
83·65	: 24·02	: 6·00 mgm. per litre.
0·0084	: 0·0021	: 0·0006 per cent.
0·167	: 0·042	: 0·012 lbs. per ton of 2,000 lb.

Corresponding manganese dioxide 0·065 lbs. per ton.

Corresponding sulphuric acid 0·074 lbs. per ton.

In this case a brown, bulky precipitate is formed, which settles rapidly, leaving a perfectly clear solution. The precipitate becomes nearly black on filtration, and probably contains some unaltered manganous oxide and a fair amount of adsorbed calcic hydrate.

Analysis of solution after completion of reaction:—

Temperature 8° C.

Oxygen, 1·0 mgm. per litre—loss 4·5 mgm. per litre.

KCN	(free)	0·010%—no change.
KCN	(total)	0·011%—no change.
NaHO		0·0084% loss—0·0056 %.
$Na_2S_2O_3$		0·012%—no change.
Na_2SO_4		Nil—no change.
KCNS		0·004%—no change.
K_4Fcy		Nil—no change.

Capacity of the bottle was 2325 cc. and 0·190 gm. of crystals of manganese sulphate was taken.

The oxygen removed amounted to 10·47 mgm. against 13·63 mgm. for the salt used, so that the efficiency was only 77% of the theoretical. A previous experiment had shown only 70% efficiency with the same amount of oxygen remaining, and it is possible that the reaction will not remove oxygen quite completely. The loss of alkalinity was nearly twice the theoretical amount, and this must be put down chiefly to adsorption. There was no trace of the formation of manganocyanides which appears to take place only in much more concentrated solutions. If the manganese sulphate were made from local black oxide ore (not a very easy matter) and the precipitate regenerated with sulphuric acid, the cost would amount to about 0·4d. per ton of solution treated. As power required for mechanical de-aeration cannot well exceed 0·1d. per ton of solution, it is clear that any chemical process will have a very severe competitor.

As pure tannin itself would be too costly for use in de-aeration of solutions, experiments were made with wattle bark, which is usually estimated to contain about 30% of tannin (only slowly soluble in cold water) and with commercial extract of wattle bark, containing up to 69% of tannin, kindly supplied to me through Dr. Caldecott. The bark was taken from local trees, dried and coarsely powdered, or, rather, pounded into shreds, while the extract was ground to pass a 200-mesh sieve; it tends to clot into gummy masses on placing in water, but dissolves completely though slowly.

(D) Comparison of extract and bark with tannin in water. Rand Water Board water used.

Initial conditions for D1, 2, 3, 4 and 5.

Temperature, 17 C.

Oxygen, 6·5 mgm. per litre.

NaHO to phenolphthalein, *nil.*

NaHO to methylorange, 0·013 %.

Stoppered Winchester quarts were used completely full of water, and the various reagents added.

(D.1) 2775 cc. 0·150 gm. tannin, and 2·8 cc. of 2N NaHO added. A dirty greenish cloud first formed changes to light brown ppt., and faint yellow clear solution, for which deduction of 0·5 must be made from oxygen determination. 21 hours.

Temperature, 18 C.

Oxygen (2·0 – 0·5) 1·5 mgm. per litre.

NaHO (P.P.) 0·0042%.

NaHO (Me.O) 0·0202%.

Loss of oxygen is thus 0·093 gm. per gm. of tannin. Loss of alkalinity (to ph. phthalein) is 0·0058%, showing a greater con-

sumption of alkalinity than with cyanide solution, but a smaller efficiency of oxygen removal.

(D.2) 2690 cc. 0·150 gm. tannin, but no soda added. Opalescent white cloud was formed, which did not change or settle in 19 hours.

Temperature, 12·5 C.

Oxygen, 4·5 mgm. per litre.

NaHO (P.P.) 0·000.

NaHO (Me.O) 0·0120%.

Loss of oxygen is only 0·036 gm. per gm. of tannin, which indicates that boiler-feed water must be made distinctly alkaline to phenlophthalein before rapid removal of oxygen can take place, and suggests that water used for making bark extract should be neutral to methylorange.

(D.3) 2630 cc. 0·150 gm. Extract and 2·6 cc. of 2N NaHO. A transparent brown solution was formed, and no ppt. showed. Colour of solution required 1·50 to be deducted from test. 19 hours.

Temperature, 12·5 C.

Oxygen (3 – 1·5), 1·5 mgm. per litre.

NaHO (P.P.) 0·0046.

NaHO (Me.O) 0·0268%.

Loss of oxygen is thus 0·088 gm. per gm. of bark. Loss of alkalinity to (ph. phthaphthalein is 0·0032 . Thus extract is almost as efficient as tannin for boiler water, and even consumes less alkali. The absence of ppt. is a further advantage.

(D.4) 2600 cc. 1·00 gm. wattle bark and 2·7 cc. 2N NaHO. The bark mostly sank to the bottom, leaving a fairly clear brown solution, requiring the deduction of 2·00 from the oxygen test. Time, 21 hours.

Temperature, 18 C.

Oxygen, (3·0 – 2·0), 1·0 mgm. per litre.

NaHO (P.P.) 0·0046%.

NaHO (Me.O) 0·0286%.

Loss of oxygen is thus 0·0147 gm. per gm. of bark. Loss of alkalinity to (Ph. phthalein), 0·0054%. This would indicate 16% of tannin in the bark, but only a poor extraction is expected in the cold.

(D.5) 2660 cc. 1·00 gm. wattle bark and no soda added. The solution was much lighter in colour than when soda had been added, and required a deduction of 1·0 from 0 test. 21 hours.

Temperature, 18 C.

Oxygen (6·0 – 1·0), 5·0 mgm. per litre.

NaHO (P.P.) 0·000.

NaHO (Me.O) 0·0140%.

Loss of oxygen is only 0·004 gm. per gm. of bark, but as was also the case with (D.2) tannin without added alkali, the alkaline ferricyanide test showed the presence of unaltered tannin. It is therefore clear that alkalinity to phenolphthalein is required to enable tannin to remove oxygen effectively.

(E) Comparison of extract and bark with tannin in weak cyanide solution.

Solution entering slime boxes was used.

Initial conditions:—For E1, 2, 3, 4 and 5.

Temperature, 17 C.

Oxygen, 6·5 mgm. per litre.

NaHO, 0·0058%.

KCN, 0·012% (free).

The same bottles and methods were used as in (D) experiments, but the time in each case was only approximately five hours. The appearance presented was much the same as in water, but the extract showed in these cases a small ppt.

(E.1), 2775 cc., 0·150 gm. tannin.

Temperature, 18 C.

Oxygen (1·0·5) 0·5 mgm. per litre.

NaHO 0·0038%.

KCN 0·012%.

Loss of oxygen is thus 0·111 gm. per gm. of tannin. Loss of alkalinity is 0·0020%, therefore five hours is evidently quite sufficient for the reaction.

(E.2), 2690 cc., 0·180 gm. extract.

Temperature, 18 C.

Oxygen (1·5 – 1·0) 0·5 mgm. per litre.

NaHO 0·0043.

KCN 0·012%.

Loss of oxygen is thus 0·090 gm. per gm. of extract. Loss of alkalinity is 0·0010%. Though sufficient extract had been added to remove all the oxygen, there was a little still left, and a trace of tannin was also shown to alkaline ferricyanide, so that the reaction does not proceed to absolute completion without some excess of tannin. However, this fact is only of theoretical significance.

(E.3), 2630 cc., 0·150 gm. extract

Temperature, 18 C.

Oxygen, (2·0 – 1·0), 1·0 mgm. per litre.

NaHO 0·0052%.

KCN, 0·120%.

Loss of oxygen is thus 0·096 gm. per gm. of extract. Loss of alkalinity is 0·0006%. A slightly better efficiency of oxygen removal is shown with cyanide than with water as in the case of tannin.

(E.4), 2670 cc. 1·00 gm. of wattle bark.

Temperature, 18 C.

Oxygen (2·5 – 1·0), 1·5 mgm. per litre.

NaHO 0·0038%.

KCN 0·012%.

Loss of oxygen is thus 0·0134 gm. per gm. of bark. Loss of alkalinity is 0·0020%. This shows only about 12% of tannin extracted in the five hours.

(E.5), 2660 cc. 1·152 gm. wattle bark.

Temperature, 18 C.

Oxygen (1·5 – 1·0), 0·5 mgm. per litre.

NaHO 0·0038%.

KCN, 0·012%.

Loss of oxygen is thus 0·0129 gm. per gm. of bark. Loss of alkalinity is 0·0020%. This also shows some slight falling off in efficiency as the last traces of oxygen are going.

Solution from (E.2) was thoroughly shaken for five minutes in a half empty bottle at a temperature of 8·5 C., and was then found to contain 8·0 mgm. of oxygen per litre, which shows that re-aeration of such solutions after extract treatment is as easy as in the case of tannin itself.

Similar experiments made with bark in cyanide solutions of lower alkalinity showed slightly worse results, though in the case of extract there was little difference, and the conclusion is drawn that an alkalinity of at least 0·008% expressed as NaHO should be present.

Summary of results of experiments on de-oxygenation of water and solutions by chemical means, calculated to show cost of removing from solution one pound of oxygen by various means.

Prices assumed in the following figures:—

Tannin ...	20d. per lb.	
Wattle Extract	4·3d. per lb.	
Wattle Bark	1·0d. per lb.	
Calcium Oxide	0·4d. per lb.	
Potassium Cyanide	10d. per lb.	
Manganese Sulphate	4d. per lb.	(crystals).
Ferrous Sulphate	2d. per lb.	(crystals).
Zinc	10d. per lb.	(cut).
Aluminium ...	20d. per lb.	

As prices are not yet stable, any serious change will require suitable alteration in results.

Average of all applicable experiments shows that removal of 1 lb. of oxygen in each case will cost as below:—

Chemical Used.	Weight Lb.	Lime Lb.	Cyanide Lb.	Total Cost Pence per lb. Oxygen.
Tannin (Cyanide)	9·24	3·9	Nil.	186·4
Tannin (Water)	10·82	8·1	—	219·6
Extract (Cyanide)	10·61	2·5	Nil.	46·6
Extract (Water)	11·41	4·3	—	50·8
Bark (Cyanide)	75·2	2·6	Nil.	77·3
Bark (Water)	68·1	7·0	—	70·9
Manganese Sulphate (Cyanide) ...	19·22	8·7	Nil.	80·4
Manganese Sulphate (Water) ...	13·94	3·5	—	57·1 (calculated).
Ferrous Sulphate (Cyanide)	35·69	8·1	9·09	197·5
Ferrous Sulphate (Water)	34·75	7·0	—	70·9 (calculated).
Zinc	4·09	Nil.	Nil.	40·9
Aluminium	1·13	Nil.	Nil.	22·6

If aluminium could be used without excessive alkali, it would be the cheapest possible chemical for removing oxygen (at pre-war prices), but even then could not compete with mechanical means, which may be put at 8·4d. per lb. of oxygen, allowing 0·1d. per ton of solution, carrying 6 mgm. of oxygen per litre.

For boiler-feed water purposes, wattle bark extract is the cheapest practical chemical, and possesses the additional advantage that its use in preventing the formation of scale is already well known. It could be fed into the final feed water line by means of a small pump from a concentrated solution made in a suitable receptacle, and is possibly worthy of trial on a working scale.

As the use of bark extract in cyanide solutions would lead to some accumulation of highly coloured and possibly undesirable organic complexes, a practical trial may well await result of mechanical methods now in progress. It is probable that no other practicable chemical means could compete.

The following experiments were made in order to determine the effect of dissolved oxygen upon the rate of corrosion of iron in water.

A piece of boiler tube was drawn down to a thickness of half a millimetre, polished and cut into rectangular pieces $1\frac{1}{2}$ x 1, or 2 x 1 cm.

In each case a piece of the metal was hung by cotton thread from a piece of glass tube to occupy about the centre of a Winchester quart bottle, and another piece was tied by thread to a piece of carbon rod which had a total surface of 80 sq. cm., and allowed to rest on the bottom of the bottle. Rand Water Board water was used in each case; this was neutral to phenol-phthalein, and showed alkalinity equal to 0·015 NaHO to methylorange. In some cases 1 cc. per litre of a 2N NaHO was added, and the change in oxygen concentration was made either by adding wattle extract or by passing a stream of purified hydrogen through the solution.

In 3 and 5 oxygen content was calculated from known effect of wattle bark added. In four the oxygen was partly removed by hydrogen, and in this case no NaHO was added. In all cases the solution became cloudy, and a precipitate of ferric hydrate was formed. A greenish tint on the iron showed that, especially with carbon contact, ferrous hydrate as well as ferric hydrate may be formed in the first steps. The precipitate formed by adding NaHO to R.W.B. water settled well, and left no cloudiness, the alkalinity becoming 0·015% NaHO to phenol-phthalein and 0·025% NaHO to methylorange.

It is evident that removal of the oxygen reduces corrosion very materially, especially where electrolytic contact is present, but a calculation of the oxygen consumed to correspond with the iron dissolved shows that it practically all is derived from the decomposition of the water.

As it was thought possible that the removal of last traces of oxygen might be accomplished by passing the water or solution over a mixture of iron turnings and crushed coke, a further experiment was made by exposing 1220 cc. of water, containing 7·0 mgm. 0 per litre for $18\frac{1}{2}$ hours, to the action of eight pieces of iron, showing 24 sq. cm. of surface, all attached to one carbon rod, with 80 sq. cm. of surface. The result, however, showed that no oxygen was removed, as the water showed 7·5 0 after

Time hrs.	Temperature.		Oxygen mgm. per litre.		Iron dissolved mgm. per sq. cm. per 24 hrs.	
	Before.	After.	Before.	After.	Free.	Carbon Contact.
42	16·5°C.	10·0	7·0	7·0	0·21	12·37
42	16·5°C.	10·0	7·0	6·5	0·24	2·32 + NaHO
42	16·5°C	10·0	4·2c	4·5	0·14	1·58 + NaHO
41	16·5°C.	9·5	2·5	2·5	0·06	0·78
42	16·5°C.	10·0	0·5c	1·5	0·06	0·72 + NaHO

the treatment, though the iron dissolved (8·5 mgm.) was equivalent to a loss of 3·0 mgm. of oxygen per litre, so that this must have been derived entirely from decomposition of water. The reduced ratio of carbon surface is reflected in the drop to 0·46 mgm. per sq. cm of iron, compared to 2·37 mgm. in experiment No. 1 above. It is therefore probable that the complete removal of oxygen from water will not entirely prevent corrosion of boilers, though it will reduce it considerably. The practice of keeping condensor return water free from agitation with air before return to boilers is therefore to be commended.

THE GOLD PREMIUM.

By S. Evans (*Associate*).

Printed in Journal, May, 1920.

DISCUSSION.

Sir James Wilson, K.C.S.I. (*formerly Comissioner of Punjab*), (*contributed*):—

The par value in exchange of gold coins depends upon the number of grains of fine gold contained in each, and, as gold is still the real basis of all international exchanges, the best measure of the present value in exchange of the paper currencies of different countries is their value as expressed in terms of gold. For instance, the United States dollar contains 23·22 grains of fine gold, while the sovereign contains 113 grains; so that at par 4·87 gold dollars exchange for one sovereign. The United States is now almost the only country in the world where gold can be obtained for paper currency at its face value, and freely exported. In almost every other country, owing mainly to the excessive issue of paper currency, and to restrictions on the export of gold, the value of the paper unit is now much below that of the gold coin it nominally represents, and therefore the exchange value of the paper unit on New York is much below par. On 24th October, the rate of exchange quoted in London on New York was 3·47 dollars to the pound, while the par rate is 4·87. This means that, while in New York a sovereign would still command 4·87 dollars, the British paper pound on that day was worth in New York only 3·47 dollars—that is to say, was worth only 71 per cent. of the value of a sovereign. On the same day in London the price of an ounce of fine gold was 118s. 2d., or 3·91 paper pounds, and, as an ounce of fine gold with the alloy makes 4¼ sovereigns, this means that on that day a British paper pound would buy in London only 72 per cent. of the gold in a sovereign—almost the same value as is given by the New York exchange rate—and as a sovereign contains 113 grains of gold, this means that the British paper pound was worth in London on that day only 81 grains of gold.

Again, the French franc contains 4·48 grains of fine gold, so that the par rate of exchange is 25·22 francs to the sovereign. On 24th October the rate quoted in London was 53·4 francs to the pound sterling; but, as the pound sterling was then worth only 81 grains of gold, this means that the French paper franc was on that day worth in London only 1·52 grains of gold—that is to say, was worth only 34 per cent. of the value of a gold franc. The New York quotation gives a similar result. The par value of the gold franc in United States cents is 19·3, but on 24th October it was quoted at 6·47 cents—that is, the French paper franc was worth in New York only 34 per cent. of the value of a gold franc—that is, would buy in New York only 1·52 grains of gold, while a gold franc would exchange for 4·48 grains. For all currencies the calculation made on the London quotations gives practically the same result as that made on the New York quotations. The fact is that, the financiers of the world being in telegraphic communication, the rates of exchange quoted at all centres go up and down from day to day in close correspondence with each other, with a small fractional difference, which cannot much exceed the cost of transporting gold from one country to the other.

Similarly calculated on either the London or the New York quotations, the values on 24th October of the paper currencies of different countries were approximately as follows:—

VALUE IN GOLD OF PAPER CURRENCIES ON 24TH OCTOBER, 1920.

Country.	Unit.	Value of the paper unit as a percentage of the value of the gold coin.	Value in grains of fine gold of Gold Coin.	Value in grains of fine gold of Paper Unit.
United States	Dollar	100	23·22	23·22
Canada	Dollar	91	23·22	21
Britain	Sovereign ...	72	113·00	81
France	Franc	34	4·48	1·52
Belgium	Franc	35	4·48	1·59
Switzerland	Franc	82	4·48	3·67
Italy	Lira	20	4·48	0·91
Germany	Mark	6	5·53	0·33
Holland	Florin ...	76	9·33	7·09
Sweden	Krona	73	6·22	4·60
Russia	Rouble	2·3	11·95	0·27
Argentine	Peso	83	22·40	18·6
Japan	Yen	102	11·58	11·8

The value of the paper currency of any one country in the paper currency of another country on any day may be approximately calculated by comparing the values in grains of fine gold of the paper units of the two countries on that day. The depreciation of the paper currency of any country is only to a small extent dependent upon its balance of trade. It is chiefly determined (1) by the relation between the supply of the country's paper currency and the demand for it; and (2) by the estimate formed by the world's financiers as to the prospects of an early diminution of the paper currency of the country, and its consequent improvement in value in terms of gold. The remedy for the depreciation in value of a country's paper currency is not so much an improvement in its balance of trade as a reduction in its outstanding paper currency by the withdrawal and cancellation of paper notes.

NOTES ON THE INFLUENCE OF SOLUBLE SILICA AND CALCIUM SALTS ON PRECIPITATION.

By J. Hayward Johnson.

Printed in Journal, October, 1920.

DISCUSSION.

Andrew King (Member): Mr. Johnson deserves the thanks of members for bringing to their notice certain causes of indifferent results in cyanide treatment. To many operators the deposition of soluble silica on zinc shavings will seem a likely explanation of bad precipitation, and affords a reason for regular washing of zinc and dressing of boxes. The effect of colloidal silica in ore-slime treatment has been previously noted (see this *Journal*, Vol. VII., p. 217), and the deposition of silica in extractor boxes has been referred to in "Rand Metallurgical Practice," Vol. I., p. 390; but the analysis of this deposit given by Mr. Johnson appears to be the first published, and is therefore all the more interesting. The exceptionally large amounts of silica found in these and other extractor box deposits by the author makes one wonder whether there is much oxidised ore or accumulated slime being treated. The analysis and reasons given by the author are all additional arguments for the taking of every precaution underground to prevent the decomposition of ore before it is delivered to the reduction works, and Mr. White's recommendation to sprinkle lime freely and leave it in contact with the broken oxidised ore should therefore be acted upon whenever possible. Incidentally it is interesting to read Mr. White's experience of the use of chloride of lime; it would be equally interesting to get the views of those who have been using this chemical, and to hear what improved results, if any, have been obtained.

So far as make-up water is concerned, from experience the writer can strongly recommend the neutralisation and settlement of acid mine water before use in the reduction works; particularly when this water is to be used in a boiler plant also, the large saving which will be effected will, in a very short time cover the initial cost of bringing such a scheme into operation (see *Journal* S.A. Inst. of Engineers, October, 1919, p. 46). In this connection it might be mentioned that under certain conditions the breaking of the drought frequently increases the amount of acid mine water to be handled on the surface, but that the gradually increasing atmospheric temperature, which is general at the same time, lessens precipitation and other troubles.

Alkalinity of cyanide solution to the extent quoted by the author would in most cases be regarded as an excess, but the extraordinary increase shown during treatment must be exceptional (in most case there is a constant decrease), and a different method of adding lime would probably overcome that difficulty.

THE KATA-THERMOMETER AND ITS PRACTICAL USES IN MINING.

By H. J. Ireland, M.B.E., B.Sc., A.M.I.C.E.

(*Printed in Journal, November, 1920.*)

Corrigenda.

On page 88, equation (4), should read:

$$Hw = Hd + (0{\cdot}085 + 0{\cdot}102\,V^{0{\cdot}3})\,(F - f)^{\frac{4}{3}}$$

and on the same page, equation (6) should read:

$$H_1 = H_0 \left(\frac{1 + \sqrt{\frac{p_1}{p_0}}}{2} \right)$$

EFFICIENT CAPACITY OF CENTRIFUGAL PUMPS.

By H. A. White (*Member of Council*).

The following figures represent average practice, but are sometimes exceeded by increasing speed of revolution and enlarging suction and delivery piping:—

Bore of pump delivery.	Cub. ft. per min.	Gallons per min.	Fluid—tons per hour.	Tons of solid per hour with ratio of liquid to solid by weight.						
				1·1	1½·1	2·1	3·1	4·1	5·1	6·1
				Specific gravity of pulp (solid taken as 2·7)						
				1·458	1·337	1·286	1·187	1·144	1·117	1·099
2″	8	50	15	11	8	6	4	3	3	2
3″	18	113	34	25	18	14	10	8	6	5
4″	32	200	60	44	32	25	18	14	11	9
5″	48	297	89	65	48	38	26	20	17	14
6″	72	450	135	98	72	57	40	31	25	21
8″	128	800	240	175	128	101	71	55	45	38
10″	200	1,250	375	274	201	158	11[illegible]	86	70	59
12″	288	1,800	540	394	289	228	160	124	101	85
14″	392	2,450	735	536	393	310	218	168	137	115
16″	512	3,200	960	700	514	405	285	220	179	151
18″	648	3,717	1,215	886	650	513	361	278	226	191

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

ASSAYING LOW-GRADE CYANIDE SOLUTIONS FOR GOLD. OURO PRETO PRACTICE.—*Apparatus.* 1. Standard $AgNO_3$ soln. (17·33 gm. $AgNO_3$ in 1 litre water. 2. A 6% lead acetate soln. 3. Filings of commercial zinc. 4. 8 oz. flask, burette, pipette, etc. Charge, say, 300 cc. in pipette, transfer to flask. Add sufficient $AgNO_3$ sol. for inquarting (about 2 cc. for sump solutions). Add about 3 gm. zinc filings. Add 10 to 15 cc. lead acetate sol. Boil. Cool. Add HCl till Zn is dissolved. Bring to boil; cool; filter while warm; giving several washes to flask. Discard filtrate. Add to filter paper in funnel sufficient litharge to cover the residue; a few gms. is enough. Have scorifiers with borax already in muffle, so that intumescence has ceased. Press down edges of filter paper to form a packet. Take out scorifier, and drop on packet. Scorify; pour; cupel; part and weigh. The assay can be done in a very short time, and is accurate. (A. R.)

THE COMMERCIAL APPLICATION OF ELECTRICAL OSMOSIS.—"After a brief exposition of some of the more important fundamental phenomena of colloid chemistry, the authors considered the application of the principles involved to the purification of clay and similar materials. The apparatus for obtaining osmosed clay consists of a tank containing at the bottom two paddles which agitate the suspension and direct it through the perforations of the semi-circular cathode. The anode is a metal cylinder, revolving at the rate of one revolution in three minutes, at a distance of about 0·75 in. from the cathode. A scraper removes the clay from the anode, where it forms a blanket up to 0·5 in. thick, containing about 25% of water. The fresh clay suspension is fed into the lower part of the tank and the water effluent is returned above to be mixed with fresh clay. A machine with a cylinder 2 ft. in diameter and 5 ft. long produces about 1,000 tons of pure clay per annum. The consumption of electricity varies from 20 to 70 units per ton of machine product.

The purified and finely-divided clay obtained in this way has many advantages. Its melting point is raised and its sintering or vitrifying temperature reduced (by as much as 300° C. for low-grade clays); the temperature interval between vitrification and incipient decomposition ("blowing") is increased. In the manufacture of porcelain and earthenware, osmosed clays yield whiter bodies, and chemical porcelain ware so made is of the very highest quality, the body consisting entirely of pure kaolin, which, owing to the fineness of the particles, vitrifies completely.

The electro-osmotic filter press for de-watering and purifying many finely-divided substances consists of a series of chambers which are closed on both sides by filter cloths held in position by perforated or grooved metal, carbon or other conducting plates, one forming an anode and one a cathode. An electrical pressure of from 20 to 100 volts, depending on the substance to be filtered, is established between the plates, and the water is forced towards the cathode. With this apparatus materials fine enough to choke an ordinary press can be filtered."—J. S. HIGHFIELD, DR. W. R. ORMANDY AND D. NORTHALL-LAURIE, Royal Soc. of Arts.—*Jour. Soc. Chem. Ind.*, 18th June, 1920, p. 198R. (J. A. W.)

METALLURGY.

HYDRO-METALLURGY OF GOLD AND SILVER.—I will briefly sketch the method now employed as a result of this work to manufacture a cheaper form of cyanide in Canada for the mining industry.

Firstly, calcium carbide is prepared by fusing coke and lime in the electric furnace; secondly, pure nitrogen is prepared from the atmosphere by the distillation of liquid air. The nitrogen is then brought into chemical combination with finely crushed calcium carbide, producing a substance known as calcium cyanamide. The calcium cyanamide is then powdered and mixed with ordinary salt, which supplies the sodium necessary in the cheapest possible form. This mixture is heated rapidly to a white heat in a special form of electric furnace, and is then very rapidly cooled to below a red heat and packed in sheet metal drums.

The various chemical and technical difficulties met with in this process have been solved so that the manufacturing process works with great facility. It is protected by a number of patents.

The Canadian plant of the American Cyanamide Company at Niagara is the first to produce cyanide commercially from atmospheric nitrogen by this process. The product contains substances other than cyanide, which are helpful in the cyanide process, and are frequently added when pure cyanide is used in the mill. This new form of cyanide is sold under the trade name of "Aero Brand," designating its derivation from the atmosphere. It contains upwards of 36 per cent. of sodium cyanide, which is equivalent to 48 per cent. of potassium cyanide, 43 per cent. of chlorides of calcium and sodium, and 15 per cent. of caustic lime. Thus, it contains cyanide for dissolving the precious metals; chlorides, to coagulate the collolids in the solution; and lime to serve as protective alkalinity. It is sold on the basis of its cyanide contents, and is delivered at the mines at a considerably lower price, pound for pound of contained cyanide, than the material heretofore imported from Europe.

The greater part of the production of the Canadian plant at Niagara Falls, Ontario, has been used for the extraction of ore in Mexico, Canada, and the Western United States, and for the fumigation of the citrus trees in California, notwithstanding the high cost of all-rail shipments from Canada.

Economy in Production of Gold and Silver. Tests carried out on the new production at the Haileybury School of Mines in Ontario showed a striking reduction in the cost of silver extraction. It is hoped that it will prove to be one of the factors which will tend to resuscitate the gold mining industry. At any event, this country is now independent of any foreign sources of cyanide, which is so vitally necessary to ensure our gold and silver production

The production of this new form of cyanide in Canada for the current year will exceed 10,000,000 lb.

Speaking of costs in the gold mining industry brings me to the second part of my subject, which deals with the recovery of gold and silver from the cyanide solutions in the mill.

The cyanide process involves two distinct steps —first, the bringing of the precious metals into solution, whereby they are separated from the matrix; and, second, the recovery of the metal from this solution. This second step has been the subject of much research, but it may be said that the knowledge of this art is somewhat limited,

and leaves scope for much ingenuity and invention.

Any process of precipitating gold and silver from cyanide solutions should fulfil at least two conditions, in order to make any advance on the present known method: It should produce a high cyanide of sodium and the noble metal, and ensure regeneration of the cyanide which was actually employed in dissolving the precious metal. In addition to possessing these points, it, of course, must be simple in operation, practicable, and show economy.

In studying the chemistry of the gold cyanide solutions, it would seem that, in order to recover the cyanide in the form in which it would again be available for dissolving gold, the obvious thing would be to replace the gold with metallic sodium instead of metallic zinc. The objection to metallic sodium is that it decomposes water with explosive force, and obviously it is impossible to use it as such for precipitating gold. In pursuing this subject, however, I was attracted by the properties of the alloys of sodium, more particularly those of lead, for reasons I will soon make clear.

Alloys of sodium and lead are very remarkable. Sodium is a much softer metal than lead, yet the addition of 1 or 2 per cent. of sodium to lead results in an alloy hard enough for bearing metal. An alloy of lead and sodium, containing 10 per cent. of sodium, is so brittle that it may readily be ground to a fine powder by hand with an ordinary mortar and pestle.

When this alloy is introduced into water, the water is still decomposed with a brisk evolution of hydrogen gas, but there is no combustion or explosion. When the proportion of sodium is cut down to 5 per cent. or under, the sodium still reacts with the water, but so slowly that the evolution of gas is barely perceptible.

These alloys, therefore, present a means of bringing sodium into the place of gold in the cyanide solution, and I have found that a total recovery of all the bullion in the solution may be obtained with perfect ease and regulation of the consumption of sodium. At the same time, the cyanogen is brought back to its original state as sodium cyanide, and therefore may be used again; in other words, a complete regeneration takes place as this reaction shows:—

$$NaCN\ AuCN + Na = 2NaCN + Au.$$

When lead-sodium alloys are used for precipitating, the lead is not affected in any way; only the sodium dissolves, and the precious metal is precipitated, yielding a mixture of gold and lead, containing upwards of 20 per cent. of bullion. The recovery of this bullion in a most desirable state of refinement is facilitated by the presence of the lead, for it is only necessary to dry, without any acid treatment, and cupel this lead-gold precipitate in the well-known cupellation furnace, sometimes used for refining the gold-zinc precipitated. The product is a bullion entirely free from base metals, and which is ready for the parting process whereby refined gold is produced.

In conclusion, I may say that several methods have been developed for production of these sodium-lead alloys requiring only ordinary salt as raw material. For this purpose it is electrolysed in the fused state over a cathode of molten lead.—HORACE FREEMAN, *Queensland Government Mining Journal*.—Paper read at Canadian Mining Institute, reproduced by *Mining and Engineering Record*, July 15, 1920, p. 280. (J. C.)

MINING.

HEALTH CONDITIONS IN COAL MINES.—Before the Industrial Hygiene Section of the Congress of the Royal Sanitary Institute, Dr. Shufflebotham read a paper in which he dealt with the health conditions of the coal-mining industry. Pointing out that this was the only European country in which there is no legislation to regulate the temperature in mines, he stated that there are many mines in this country where the wet bulb temperature exceeds 80 deg. Fah., and some seams in which the temperature is 90 deg. Fah. It was not surprising, therefore, that coal miners should be subject in a greater degree than the general community to arterio-sclerosis and to chronic lung disease, particularly bronchitis, asthma and emphysema. It was to the low candle power of the safety lamps that miners' nystagmus could be traced; and he was of opinion that the poor light in all mines was a contributing cause to the large number of accidents there. It was confidently believed that by the compulsory introduction of suitable lamps of between 1· and 1·5 candle-power nystagmus could be checked, and in from seven to ten years entirely wiped out. In some mines in Yorkshire electric lamps of a still higher candle power were being used with good results, while ambulance arrangements at all collieries were most efficiently organised for the treatment of serious cases.

The author went on to say that tens of thousands of miners disabled by sprains of muscles and joints were treated at home under the National Health Insurance Act. This treatment simply consisted of applying liniments prescribed by the panel doctor, and amounted to no treatment at all; it was responsible for the delay in recovery. In practically all such cases, if up-to-date methods of treatment were applied, the duration of incapacity for work would be at least halved. He recommended that provision be made for reducing the temperature of hot seams in which miners work, and that employment should be forbidden where the wet bulb thermometer exceeded 77 deg. Fah., the standard adopted in France. He also recommended the introduction without delay of lamps of increased candle power; increased and improved inspection; monthly or weekly notification of accidents; the publication of such notifications in the newspapers, with a view to creating a public opinion on the subject and stimulating the mine management to a greater efficiency in prevention; the establishment of a medical officer attached to each mine, which should be provided with a fully equipped surgery, and the establishment in every colliery district of an institution of the type of an orthopædic clinic. Investigation should also be made as to the causation and prevention of such miners' diseases as beat hand, beat knee, and the skin diseases to which miners were specially prone.—DR. SHUFFLEBOTHAM, *Iron and Coal Trades Review*, Aug. 1, 1919, p. 145. (J. A. W.)

MISCELLANEOUS.

MINERALS IN THE S.W. PROTECTORATE.—"The British Trade Commissioner at Capetown reports that although the Protectorate of South-West Africa has not yet been fully explored, it seems probable that it contains but little coal. The existence of coal deposits about 40 miles west of Itzawasis was

known by the German Government, and they reserved an area of 14,000 square miles in which private prospecting was forbidden. This area embraced the eastern portion of the Gibeon district, and prospecting by the Government was proceeding when war broke out. Copper ranks second to diamonds in importance amongst the minerals of the Protectorate. The principal concern engaged in copper mining is the Otavi Mining and Railways Company, which was registered in Germany in 1888 with a capital of £200,000. The export of tin began in 1911 with consignments of 9 tons. By 1913 the exports had risen to 200 tons. Ninety per cent. of the best tin claims have been acquired by British companies. The output of tin in 1918 amounted to 65 tons, assaying in the average 68 per cent."—*J. and C.T. Review*, August 13, 1920, p. 199. (J. A. W.)

THE FUEL POSITION IN ENGLAND.—"The Fuel Research Board in a recent report states that the estimated petrol requirements of this country for the present year amount to 250,000,000 gallons, and the possibilities of other fuels for traction have been fully investigated. It has been concluded that the production of power alcohol from potatoes, barley, etc., is not economically possible in this country. The production of benzol from coke ovens and gas works in this country during 1919 was 20,000,000 gallons, and it is not anticipated that this figure will be improved upon to any great extent during the present period. It is suggested that town and coke-oven gas might be extensively used for omnibuses and passenger traffic generally, safe containers could be constructed, and charging stations established on all principal routes."—*Ind. Engr.*, August 28, 1920, p. 121. (J. A W.)

Abstract of Patent Applications.

31.20. J. H. Mitchell and another. Improved tappet and casing for hammer drill machines. 13.1.20.

This application refers to tappet drills of the air-feed, hand-oscillated type, in which water is passed through the tappet to hollow drill steel.

The claims are for a tappet of specific form, a suitably shaped casing to accommodate the tappet, and a packing ring of specific form.

According to this application the tappet is formed with a laterally extending arm to which a water hose is attached. This arm extends through a slot in the tappet casing, and is suitably bored to convey water to the axial bore of the tappet.

710.20. F. Hammond. Improvements in liquid measuring. 5.7.20.

This application refers to a liquid measuring apparatus, this combining with a measuring vessel or bowl and a supply tank of a valve adapted to control the passage of liquid from the tank to the bowl, and one or more tubes slotted at different levels in the said bowl, each tube being provided with a disc below its respective slot through which any surplus liquid is returned to the supply tank substantially as described.

Other claims refer to details.

725.20. Worthington Pump and Machinery Corporation. Improvements in valves. 9.7.20.

This application refers to a valve comprising united seat and cap sections forming a valve chamber between them and loosely confining an unsecured plate valve of light mass, the cap section being provided with flow passages at both ends of the valve plate, serving to guide the valve plate and keep the valve seat free from dirt

726.20. Worthington Pump and Machinery Corporation. Improvements in automatic plate valves. 9.7.20.

This application refers to a valve construction of that class having one or more valves formed of a thin elastic plate free to bend uniformly in opening, in which the valve seat is a plain surface, and the valves are held in position and guided by means separate from the valve seat.

764.20. La Societe Le Cokre Industriel. Improvements in apparatus for the separation of coke or carbon from slag or the like. 15.7.20.

The above application deals with improvements in apparatus for the separation of coke or carbon from slag or the like. It is really an improvement on the applicant's previous patent No. 502.19.

The principal feature of improvement claimed is that in the separating compartment plates are arranged in two parts and have a double joint which allows of their inclination, and consequently the widths of the upper openings of the compartments to be varied at will, so as to vary the speed of circulation.

777.20. Frederick Handley Page and Handley Page. Improvements in the wings and similar members of aircraft. 15.7.20.

This application refers to improvements in the construction of aeroplane wings, each wing being constructed with a small forwardly located auxiliary wing, separated from the main wing to produce a comparatively narrow through slot or its equivalent, extending substantially throughout the wing in a direction transversely of the line of flight, the said auxiliary wing having its nose located at the approximate level of the nose of the main wing and having the angle of incidence of said auxiliary wing less than the angle of incidence of the main wing so as to mask the leading portion of the latter. Other claims refer to modifications and details.

Changes of Address.

HEBBARD, A., *l/o* Newlands Avenue, Benoni: New Modder G.M. Co., Ltd., East Reduction Works, P.O. Box 25, Benoni.

MEIN, W. W., *l/o* Tahoe City, Cal.; 45, East 82nd Street, New York, U.S.A.

NEAL, WALTER, *l/o* Montreal; Hotel Cosmopolita, Guadalajara, Jalisco, Mexico.

NEILL, J. M., *l/o* Johannesburg; Slaaihoek Mines, Ltd., P.O. Airlie, Transvaal.

TOPPER, G. E., *l/o* Krugersdorp; 8, Melville Street, Booysens, Johannesburg.

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TREATMENT OF ANTIMONIAL GOLD ORE AT THE GLOBE AND PHENIX GOLD MINE, SOUTHERN RHODESIA.

By V. E. Robinson, (*Member*).

The present treatment of this ore has been evolved after many years' experience and study of its characteristics.

Earlier methods, now more or less superseded, have been described by H. T. Brett* and H. N. Spicer,† so that it is unnecessary to refer further to them here, except to state that all changes have been in the direction of greater simplicity and lower working costs.

An analysis of the ore given by Mr. Brett is as follows:—

	%
SiO_2 and insoluble.	76·32
Sb	0·73
Fe	2·58
S	0·96
CaO	1·21
MgO	6·44
As	Trace.
Cu	Trace.

The amount of antimony, however, varies considerably, thus screen samples, taken over a period of three weeks, have contained as much as 2·39% Sb and 0·26% As, while the massive stibnite removed by sorting contains up to 80% Sb_2S_3.

Much of the gold present in this ore is free, and easily caught on amalgamated plates; some of it is coated, but is amalgamated in grinding pans, and some escapes the pans and is retained on canvas strakes.

Owing to the stibnite present, and also possibly to ferrous iron, the tailing cannot be treated directly by cyanide, but if it be allowed to partially oxidise by weathering, it becomes amenable to cyaniding.

The following is an outline of the present method of treatment:—

After breaking and sorting, the ore is wet crushed by stamps and passes over amalgamated plates to grinding pans. It then flows over canvas strakes to a classifier, which separates sand from slime. The sand is discharged to dump; the slime to dams. Both products are allowed to oxidise by weathering, after which the sand is ground in tube mills in cyanide solution, and treated by counter current continuous decantation, while the slime is treated by the ordinary decantation method.

Details of Treatment.

Breaking and Sorting.—The ore is trammed from the shaft bin, and dumped on steel grizzlies, with 1½ inch openings and set at an angle of 50°. The oversize is fed to two 15 in. x 9 in. Blake-Marsden breakers, whence it is conveyed by belt to a screening and washing trommel. Fines go direct to mill bin; the remainder, before entering the bin, is fed on to a sorting belt, where waste rock and stibnite are removed, and discharged to their respective dumps. About half a ton of massive stibnite is sorted out per day. The greater portion of the stibnite remaining in the ore is present in the fines.

Crushing and Amalgamation.—The mill is equipped with 40 stamps of 1,250 lb. weight. Using 200 mesh screens, with a drop of 8½ inches, and making 108 drops to the minute,

* *Mining Magazine*, July, 1911.

† *Mexican Mining Journal*, October, 1913.

the stamp duty works out at 5·75 tons. From the mortar boxes the pulp flows over eight amalgamated copper plates, 12 feet in length, of which the lower 4 feet is covered with blanket.

From the plates the pulp passes to twelve 5 ft. grinding pans, to which mercury is added. These pans run at 48 R.P.M. Their shoes and dies are made on the mine; a set lasting on an average, 60 days. The pan discharge passes over canvas strakes, then through three mercury traps, to a large launder designed as an auxiliary mercury trap, thence to the tailing pump. This mercury trap is very efficient. It consists of a wide launder having several layers of heavy screening (½ inch aperture) fastened to the bottom.

The strakes cover a rectangle 19 feet long by 53 feet broad, and are stepped in the centre. The strake product is reconcentrated over a small strake, the discharge of which passes back into the grinding pans. This concentrate is very fine, so that during barrel treatment it is mixed with coarse river sand, and a few tube mill pebbles. To promote efficient amalgamation a little sodium cyanide is added, which acts as a desulphurising agent, keeping the mercury clean. It dissolves no gold.

From 65% to 70% of the gold content of the ore is recovered by amalgamation, of which 60% comes from the plates, 13% from the blankets at bottom of plates, 19% from the pans and 8% from the canvas strakes.

Mr. R. W. Copley, the Battery Manager, who has had considerable experience of blanket and canvas concentration, has furnished some valuable notes, from which the following is extracted :—

"The width of the strakes is of more importance than their length, and if, through insufficient space, their width must be curtailed, it will be found advantageous to instal step tables, with a drop every 6 feet. The fall should be 1½ inches per foot, and a convenient size for each strake is 30 in. wide. The blankets should not be more than 36 in. long—this length being handled easily. Canvas is superior to blanket in saving fine gold."

When first discharged both sand and slime have a dull bluish-grey appearance, but as oxidation proceeds this changes to a yellowish colour.

Sand Treatment.—The capacity of the sand plant is 300 to 320 tons per 24 hours, and an extraction of 75% to 80% of the gold content is obtained

Grading analysis of dump sand before regrinding, shows :—

5%	+ 30	mesh.
24%	− 30 + 60	,,
25%	− 60 + 90	,,
18%	− 90 + 150	,,
28%	− 150	,,

Different sections of the sand dump, however, vary a great deal, and the sand now being discharged from the mill contains only 25% + 90 mesh after regrinding, residue grading shews about 15 to 20% + 150 mesh.

The tube mill pebbles used are obtained from adjacent river beds. Waste rock has been used, but is inferior to these pebbles.

The cyanide strength is kept at about 0·03% KCN in the tube mill circuit and agitators; 1·1 lb. cyanide and 0·2 lb. lead nitrate are consumed per ton. The sand is conveyed from the dump to the treatment plant by mechanical haulage.

Slime Treatment.—The dams for accumulating the current slime occupy an area of about 5 acres; divided into three separate portions, each being 6 ft. deep, so that, while one is being filled, another is full awaiting treatment, and the third is under treatment. When a dam is full, it is allowed to dry sufficiently to hold the weight of the oxen and plough. The whole surface is then ploughed over several times, at intervals of five to six weeks.

When treatment is commenced on a dam, half the ploughed area is removed to a depth of 14 inches, and taken to the treatment plant. The rails are then shifted to the other half of the ploughed area, which in its turn is treated, and while treatment of this second half is proceeding, the first half is reploughed several times. This procedure is continued until the dam is exhausted. The ploughed and oxidised slime is trammed by oxen to a vortex mixer.

The cyanide treatment is carried out in circulation and decantation tanks, circulation and transfer being effected by pumps.

The cyanide consumption is about 1·6 lb. per ton treated. An extraction of close on 80% of the gold content is obtained.

Clean-up and Smelting.—Precipitation on the whole is good, although the zinc is apt to become plated with gold. The solution from the sand treatment plant gives far less trouble than that from the slime plant, and the products of the two plants are kept

separate throughout clean-up and smelting. In the slime boxes, a varying amount of copper is precipitated in the lower compartments.

The smelting equipment consists of a paraffin oil fired tilting furnace, taking a No. 400 crucible; three coke furnaces; one two-tray calcining furnace, and a retort. Slags, and other by-products are treated in a Taverner furnace. The retort is of the usual design. A small amount of antimony present in the amalgam, causes objectionable fuming when taking sponge from retort, and also makes the gold very brittle.

After smelting the precipitate from the sand plant, it is refined by remelting with an oxidising flux in clay-lined pots; skimmed, and a blast of dry compressed air allowed to play on the surface of the molten metal, for from one to two hours. The iron pipe ½ inch diameter, delivering the air, is kept about 4 inches from the surface of the metal, and just sufficient air turned on to give a faint ripple over the surface; antimony, and other easily volatilised metals come off in dense fumes until completion of the operation. The bars are cast under a borax cover, and assay over 800 fine.

The "slime" bullion requires different treatment owing to the large amount of copper often present. It is granulated; mixed with sulphur, and heated slowly in a graphite pot. Most of the copper and other base metals, as well as part of the silver, enter the matte, but antimony is not entirely removed. After the charge has been fused, poured, and the matte removed, the bullion obtained is remelted in a clay-lined pot with an oxidising flux, then skimmed and toughened by compressed air.

The matte is crushed fine, mixed with an equal weight of borax, and quarter its weight of crushed cyanide, and heated in a graphite pot until all action ceases. The matte is now decomposed, and practically all the gold and silver is recovered as fairly good bullion, which is further refined by oxidation, and is then included with the bullion obtained from the sulphur treatment.

Treatment Considerations.—A considerable amount of experimental work has clearly demonstrated the desirability of weathering before treatment.

An illustration of this is shown in Table I., which gives the result of a large scale test conducted in the plant under working conditions. The strength of solution was maintained between 0·03 to 0·035 KCN during both tests.

TABLE I.

Material Treated	Period of Test Days.	Tons Treated	Head Value.	Total Residue	Extraction percent	Cyanide Used.	Lime Used
			dwts	dwts.		Lb. p ton	Lb. p ton
Weathered Sand ...	7	1890	6·1	0 97	84 2	1 5	2
Current Sand	5	1002	7·5	2 96	60·5	2 8	Nil.

The period required for oxidation varies according to conditions. The slime might remain in the dams for years, without any visible change taking place, but as soon as it is ploughed, and thus exposed to the air, the change to a yellowish colour commences. Under the best conditions, slime will oxidise sufficiently for treatment in about 20 days. Under working conditions each half of a dam will receive two ploughings in approximately six weeks. As a general rule, the sand will be on the dump over six months before it is treated, though under favourable conditions, such as small bulk, it would be ready for treatment in a much shorter period. Occasionally, when the antimony contents are low, a fairly good extraction may be obtained without preliminary oxidation by weathering. The use of a certain amount of lime in treating the oxidised material is desirable, as it decreases the cyanide consumption, but too much is fatal to a good extraction.

My thanks are due to Mr. T. Haddon, the General Manager, for permission to publish the information contained in this paper.

NOTES ON THE INFLUENCE OF SOLUBLE SILICA AND CALCIUM SALTS ON PRECIPITATION.

By J. Hayward Johnson (*Member of Council*).

DISCUSSION.

Mr. John Watson *(Member of Council)*: The author is to be congratulated on his paper, as treating of a subject of perennial interest, namely, "Silica Separating from Solution." Some time ago the writer, was

engaged in a quest for fresh water, to be used for steam-raising, near the Zoutpan, Haaman's Kraal district. About a mile, south-east from the Pan, a spring or pond was found, which was soapy or milky in appearance. It is said such springs are common in the Barberton district. This was evidently a case of a natural water containing a soluble silicate; through the action, probably of carbonic acid, a portion of the silica had been thrown out of solution, but remained in a suspended condition.

In the Streatfield Memorial Lecture, on "The Gases Dissolved in Water" by Mr. J. H. Coste, F.I.C., delivered on the 14th October last, at the Finsbury Technical College, the author gave the solubility of carbon dioxide in water, as follows:—

1 cc. of water dissolves

Carbon dioxide

at 0°C.	10°	20°	30°	40°C.
1·71 cc.	1·19	0·88	0·665	0·530cc.

according to Winkler. See "The Chemical Age," Vol. III., No. 71, p. 417.

Anyone who has preserved eggs in "water-glass" (sodium silicate), may have noticed that on keeping such a solution (say in a cleaned paraffin tin of 4½ gals. capacity), the solution after some time becomes milky or soapy in appearance.

The zinc extractor-boxes of a gold reduction plant are often worked continuously, during the life of the mine, the only cessation being for clean-up purposes, say, bi- or tri-monthly. The conditions of the solution may be varied by many factors:—(a) the composition of the ore, (b) water supply, (c) lime, (d) chemical composition and physical condition of zinc, and (e) temperature.

"*White Precipitate*" has formed the subject of more than one discussion before the Society. According to Dr. B. Bay this was chiefly zinc hydrate.

Mr. J. Hayward Johnson mentions two samples from the East and West Rand, which contained, in round numbers 38% and 39% silica respectively. In 1910, the City and Suburban plant had trouble with a *cream-coloured* precipitate, of a light and flocculent nature, which formed in the steady-head vat and sand extractor boxes. I was given a sample of this for anaylsis, and the dried matter gave:—

Magnesium Carbonate	53·47
Calcium Carbonate	15·36
Zinc Hydrate	11·93
Alumina and Ferric Oxide	8·76
Silica, etc. (insol. in dil. HCl)	4·06
Sodium Sulphate	3·57
Chlorides, Alkali, and Cyanide, undetermined: by difference...	2·85
	100·00

A dried sample of similar precipitate gave 9·6 dwt. fine gold per ton.

Mr. Johnson quotes analysis of a lime containing magnesia—7·2%. One can easily understand a mine water, containing free sulphuric acid, forming magnesium sulphate on being neutralised with such lime. The action of CO_2 on such a solution would be to precipitate magnesium carbonate.

REMARKS ON BULLION SAMPLING.

By J. H. D. James, A.I.M.M. (*Member*).

(*Contributed.*)

As an assayer I read with great interest the remarks by Mr. Wilkes on the above subject, as recorded in the November *Journal.*

I am in entire agreement with Mr. Wilkes on the points he has raised, and particularly on the custom of judging the accuracy of the Rand assayers' work by the closeness of agreement of the fineness of a bar in parts per 1,000. To my mind this is fallacious, the real test is the nearness of value, or fine gold as returned by the buyer as against the seller's estimate.

The Rand assayer is placed in an unfair position owing to the fact that London returns are usually considered to be infallible, and errors in describing bars and their samples are presumed not to occur in London.

As illustrating the last remark, I have been permitted to state what occured with three bars from this mine during the past year. These consisted of two mill bars and one cyanide bar from the same monthly smelting. I give below the

weights of the bars, mine fineness, London fineness, mine fine oz., London fine oz.

Bar No.		Weight of Bar.	Mine Fineness.	London Fineness.	Mine Fine Ozs.	London Fine Ozs.
Mill	A	771·299	908·7	913·0	700.880	703·877
	B	774·399	913·2	909·0	707·182	703·566
Cyanide C		715·050	904·4	912·0	646·691	651·715

The mine secretary drew my attention to this when the returns were received from London. I re-assayed the samples, and reported practically identical results with those first obtained.

It will be observed that taking the two mill bars together there is only a difference of 0·619 oz., which may be considered permissible when one allows for loss in re-smelting.

The difference in fine oz. between these two mill bars is in fact less than that of two other mill bars taken at random, which gave the following results:—

No. of Bar.	Weight of Bar.	Mine Fineness.	London Fineness.	Mine Fine Ozs.	London Fine Ozs.
C ..	908·55	910·3	910·0	827·053	826·370
D ..	906·75	894·5	894·5	811·088	810·730

With these bars there is a difference of 1·040 oz. It will be noticed that although the assay results of bar D are identical, there is a difference of 0·358 oz. of fine gold, which shows the fallacy of judging by identical results in parts per 1,000.

In the following example the reverse is the case; there is a difference of 0·5 thousandths in fineness, but the actual fine gold is much closer than where the fineness was identical.

Weight of Bar.	Mine Fineness.	London Fineness.	Mine Fine Ozs.	London Fine Ozs.
950 40	909·5	910	864·389	864·409

In the instance quoted by Mr. Wilkes, although there was a difference of 16 points in fineness, the difference in fine gold was only 0·2 oz., which even if we put the high value of £6 per fine oz., is a matter of 24/- on a value of £1,500.

With regard to the two mill bars A and B, the question arises, who is to blame? Was the error in describing the bars and their samples made here or in London? That point will, I am afraid, never be cleared up, but as the difference in fine oz. of the two bars together was not great, no notice was taken of it; the case was a clear one of the crossing of samples either here or in London. With regard to the cyanide bar C, this is a case which admits of arbitration, as there was a difference of 5·024 fine oz., but the check assays in London came out at the higher figure.

I quite agree that the disabilities are lessened as the fineness of the gold improves, and that it is with gold below 800 fine that trouble is likely to occur.

It would be more satisfactory to assayers if, as Mr. Wilkes suggests, when the refinery is established, a standard method be adopted for the preparation and sampling of the metal.

I daresay most assayers could give instances similar to those I have given, but I think they show how fallacious is the reasoning whereby only agreement in actual fineness is considered, and not the agreement in fine oz. or value, because after all, the assayers work with regard to bullion is to ascertain its value.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Welsh Coal By-products.—The system of by-products recovery begins with the carbonisation of coal in the manufacture of coke. All coals have a well-defined decomposition point, but for by-products purposes there are two distinct temperatures at which the coal may be heated. The first method is known as the low carbonisation method, and is employed in the United States. This method is not employed in South Wales, where the coal is burnt for about 36 hours at a temperature of 900° to 1,000° C. The by-products resulting from this process are of the aromatic series such as benzol, naphthalene, anthracene, etc.

The gaseous vapours from the coke ovens consist of permanent gases, saturated with tar, benzole and ammonia. The first dealt with are the tar gases. By means of mains or pipes, all the gases from the coke ovens are conveyed to condensers containing tubes through which water is forced. The gases are drawn by means of an exhaust through the condenser, but of course outside the tubes and in the opposite direction to which the water is travelling. This cooling of the gas brings down most of the tar in liquid form, when it is run off to the separating tank. There is still, however, a certain amount of tar gas left in the gases in the

form of little globules, and this gas is sucked by the exhaust through a system of plates having small perforations in different places which split the gas into small jets, each of which is drawn through one perforation on to the cool surface of a plate behind, the globules thus being gradually broken up. This condensation also brings down a certain amount of ammonia in liquid form, but this difficulty is soon remedied in the separating tank, the ammoniacal liquor remaining on the surface and the tar sinking. The tar may now be sold as such, or preferably worked up in the tar stills, and further split up into anthracene oil, creosote, naphthalene salts, and pitch.

The Ammonia Gases.—With regard to the ammonia gases the reason why all the ammonia compounds are not condensed in the condensers is that other bodies having a stronger affinity for ammonia are present in the gas, and these cling to the ammonia in the form of compounds, which have to be broken up. Some of these are easily decomposed by mere heating, while others require in addition to heating the presence of an alkali such as soda or lime to bring about decomposition. The gases are now put through what is known as a tower scrubber, which consists of a tower about 70ft. high containing two cylinders packed with wooden boards 6in. wide and ⅝in. thick, set on edge and ½in. apart, alternate layers being at right angles to one another. Water is listributed over the whole area at the top, gas entering at the base in the opposite direction to the water. As ammonia is very soluble in water, a certain amount is extracted in this process. The gas is then put through another form of scrubber of the rotary, horizontal type. This scrubber is divided into sections, each of which contains numerous brushes, the bristles being made of steel. Water passes through these sections at the bottom, the brushes revolving in each section and dipping into the water. The gas passing through at the top of the sections in the opposite direction to the water is forced through the interstices of the brushes which are moist. Thus the gas containing the final and weakest traces of ammonia meets the strongest and purest water, and all ammonia which is capable of being absorbed is run off as ammoniacal liquor, together with the ammonia in the form of compounds. The liquor is then subjected to steam and milk of lime, which splits up the ammonia compounds, and the ammonia remaining is made to bubble through a bath of sulphuric acid, the strong affinity of these two bodies for each other causing a reaction. It is now a very simple matter to crystallise out the sulphate of ammonia.

The tar and ammonia being thus segregated from the gases only the benzol remains to be dealt with. Once again a body having a strong affinity for the product required is utilised, and this time it is creosote oil. A tower-scrubber containing three towers on the same principle as the ammonia scrubber is used, creosote oil trickling down over the wooden packing in the tower, and the gas passing up through the tower. For this process three towers are usually employed, the fresh creosote oil being introduced at the third and the gas at the first tower scrubber, the oil and the gas travelling in opposite directions. Thus the strongest creosote oil meets the weakest traces of benzol. The creosote, having absorbed the benzol from the gas, is now run off to storage tanks, and the next step is to separate the creosote oil from the benzol.

The boiling point of creosote oil is about 250° to 300° C., and of benzol about 80·5° C., consequently it the benzolised creosote oil is heated to between 110° C. and 170° C., the benzol will be given off as vapour, and the creosote oil will not boil, but will run back and so be used again and again. The oil is therefore pre-heated in three stages to between 140° C. and 170° C., and passed to a still constructed on the principle of the ammonia still, where passing over successive trays it is thoroughly agitated by steam, the benzol being expelled. The crude benzol is then pumped to the benzol washer, where sulphuric acid is added to it to extract pyridine (one of the impurities present in the benzol), as the latter has a strong affinity for sulphuric acid. The benzol is next washed with caustic soda, which combining with one of the other impurities, namely, phenol, is run off. The washed products are now conducted to a final rectifying still, and from this to the fractionating still, where (as the name implies) they are split up into refined benzol, toluol solvent, and heavy naphtha. This splitting up is carried out by a careful regulating of temperatures, each of the above constituents of crude benzol having a distinct boiling point. It is thus merely a matter of careful regulation of temperatures, in order to vaporise first one and segregate it, and then the others in turn.

The gas now contains a certain amount of sulphuretted hydrogen, which, being of a very poisonous nature, has to be eliminated. To accomplish this, the same plan is adopted as before. In this case the commodity used is bog iron ore, through which the gas is passed. The sulphuretted hydrogen remains in the ore, leaving the gas sufficiently pure to be stored in gasometers for household purposes.

The Endless Chain.—The system is not yet complete, however. The sulphur in the ore must not be wasted, so it is burnt, and the sulphur gas liberated. This gas is conveyed to the acid plant, where, by mixing with saltpetre, sulphuric acid (required in the manufacture of sulphate of ammonia) is obtained.

In the settling out of the oils in the tar plant and the spirit in the benzol plants a certain amount of crystallisation takes place, in the form of naphthalene salts. Pure naphthalene is not yet being made by South Wales collieries, but it is only a question of time before this is carried out.

The foregoing description is an attempt to describe the system as generally in use at present in South Wales, and this article does not by any means exhaust the possibilities, as the by-products recovered could be very considerably extended. It represents, however, roughly the distance to which it has been found practicable to carry the process in South Wales. The small coal used in this part of the country is not particularly good for recovery purposes and does not compare favourably with many English coals.—*The Times Trade Supplement,* 18th December, 1920. (W. A. C.)

METALLURGY.

Electrical Precipitation for Silver Fumes.—"An installation has recently been made in the silver refinery of the United States Metals Refining Co., Chrome, N.J., which is of special interest, as the substance is not a fine, dry, easily-handled dust, but a semi-liquid sludge, that is hard to remove, and is specially liable to build up on the electrodes

and cause earths. It also contains a considerable percentage of selenium compounds, which not only attack iron and steel, but ordinary commercial lead also, and only lead free from antimony can withstand destruction from the selenium-carrying gases. Hence, every part of the equipment with which the fumes come in contact must be covered with chemically pure lead. According to the *Electrical News* the treater installation consists of three units of 30 lead-lined tubes each. The electrode system, in this case at 65,000 volts, contained in the tubes is rigidly suspended from the top, so that bottom insulators can be dispensed with. The gases from the furnaces are first passed through scrubbers and sprayers, which remove a portion of the fumes and cool and moisten the gases to the proper degree. They then pass into the top of a large header, into which the precipitating tubes project several feet, so that irregularities in the gas flow are broken up, all the pipes are heated to the same temperature, and a uniform flow is established through each pipe. After passing through the pipes, the gases now free from fumes, escape into the atmosphere. As soon as the maximum permissible amount of precipitation has taken place in the pipes of any unit, the gas flow and the electric current to that unit are cut off, and the precipitate is flushed out of the pipes by a washing system. The electrical equipment consists of a motor-generator set, a high-voltage transformer, and a mechanical rectifier. The motor-generator set is made up of a 10 h.p., 220-volt Westinghouse D.C. motor, and a 25-k.v.a., 220-volt, 60-cycle Westinghouse A.C. generator. The motor is driven from the power circuit of the plant and the generator supplies the current for the precipitation system. The low-voltage current from the generator goes to the transformer, which is of a special design, made by the Westinghouse Co. It is of 25 k.v.a. capacity; takes low voltage current at 220 volts, and has taps in the low tension winding for transforming to 55,000, 65,000, 70,000 and 75,000 volts respectively. After the low-voltage A.C. has been transformed to high-voltage it goes to the mechanical rectifier, which is a simple form of commutator, and is kept in synchronism with the current by being mounted on the generator shaft.—*Indian Engr.*, Sept. 11, 1920, p. 149. (J. A. W.

MINING.

Mining Detonators.—The report includes a resumé of experiments performed by F. H. and P. V. Dupre on the sensitiveness of fulminate mixtures and detonators.

It was proved that the sensitiveness of the mixtures depended upon the fulminate and that of the fulminate on the size of the crystal.

In the case of the finished detonator, the original sensitiveness of the fulminate has little or no influence on the sensitiveness of the finished detonator as the pressure applied to the latter after priming is sufficient to reduce the fulminate to a very fine powder, in which condition all of a very large number of samples examined gave approximately the same figures for sensitiveness.

The resumé continues with useful information to the manufacturer regarding the jelly bag mixer and finishes with remarks regarding the destruction of fulminate and detonators. The method of chemical destruction by the use of hyposulphite for the fulminate is strongly condemned for use in the case of the finished explosive.—Forty fourth Annual Report of H.M. Inspector of Explosives, January 1, 1920. (W. B. J.)

MISCELLANEOUS.

The Role of Fatty Acids in Lubrication.—Hitherto, free fatty acids in lubricants have been judged mainly by the injurious effects which they are capable of causing, and their presence has come to be regarded as wholly objectionable; but Messrs. Wells and Southcombe, in their interesting communication to the London Section on February 2, now show that, in strictly limited amount, free fatty acids are capable of greatly improving the friction-reducing values of mineral oils, and that the improvement in "oiliness" or lubricating power of a mineral oil, caused by mixing with it a fixed oil, is due far more to the small quantity of fatty acid contained in the fixed oil than to the neutral glyceride.

Some figures quoted by Mr. Archbutt in the discussion illustrate this point very forcibly. In some experiments made with a Thurston machine under conditions of very low speed and high pressure, so as to ensure a certain amount of solid friction between the bearing and the journal, it was found that 0·5 per cent. of rape oil fatty acids added to a mineral oil reduced the friction coefficient from 0·0066 to 0·0049, whilst nearly 60 per cent. of neutral glyceride of the same rape oil was required to produce the same effect. It appears, therefore, that this discovery affords the means of diverting to other more useful purposes the greater part of the saponifiable oils and fats which are to-day used for blending with mineral oils, and of employing in their stead a very much smaller proportion of free fatty acid.

The authors' theory that the action of the fatty acid is due to the fact that the interfacial tension between oil and water and between oil and mercury is greatly lowered by the addition of fatty acid to a mineral oil met with a good deal of criticism, and it was pointed out that, although neutral rape oil added to mineral oil greatly reduced the friction coefficient, the inter-facial tension between neutral rape oil and water was nearly as high as that between mineral oil and water. In the lubrication of a shaft or journal running at a fairly high speed and under moderate pressure, the bearing is separated from the journal by a film of oil, and the friction is solely due to the viscosity of the lubricant. That property of a lubricant which is not viscosity and is termed "oiliness" only becomes important when the conditions are such that solid or "contact" friction occurs, and all recent work points to the facts that it is the chemically reactive and unsaturated constituents of lubricants which promote "oiliness," and that they do so by entering into physico-chemical union with the solid faces lubricated, forming new composite surfaces with lower surface energy and opposing less resistance to shear than the unlubricated surfaces. The great activity of free fatty acids is quite in accordance with this theory. Messrs. Wells, Southcombe and Archbutt are to be congratulated on having made an important addition to our knowledge of lubrication.—*Journ. Soc. Chem. Ind.*, Feb. 16, 1920. (A. McA. J.)

Abstract of Patent Applications.

821.19. E. C. Henson. Wireless transmission of energy. 9.10.19.

In this application a method is described of communicating by telephone in a limited area without transmission wires. The chief feature is the use of iron core reactors, which enable waves of low frequency to be used, such as from the voice in speaking, instead of high frequency, as in radio installations, in comparison with which it is claimed that there is freedom from atmospheric disturbances, no interference from radio installations or from similar installations as the one described, outside the limited area involved.

25.20. Henry S. Potter. Improvements in Rock Drills. 9.1.20.

This application refers to rock drills, of either the hammer or reciprocating type, in which water is supplied to hollow steel through a packed tappet or through an axial tube.

It has for its object the prevention of leakage of water from the water supplying means to the working cylinder of the machine where the presence of water is undesirable.

To this end it is proposed to provide an annular space suitably positioned for the collection of the leakage water, and to connect this annular space with passages arranged in the form of an air ejector which latter is operated by the exhaust from the machine.

It is claimed that the air ejector will produce a partial vacuum in the annular space provided for the collection of leakage water, and thus prevent the latter from reaching the working cylinder.

53.20. Laminated Coal, Ltd. An improved solid fuel. 17.1.20.

The patent applied for is for the manufacture of laminated fuel made from coal dust, coke, wood dust, or mixtures of coal, etc.

The fuel is produced either in the form of briquettes or irregular shaped lumps of coal, and is produced by the same method and means as usually employed in coal briquetting, the difference being that the briquettes or lumps of fuel are made up in layers which adhere together well when cold, but easily part when heated. This is brought about either by cooling, or sprinkling hydrated lime, coke dust or any such-like substance between successive layers, the object of laminating the fuel being to make it burn more readily than solid briquettes.

778.20. A. Redler. Improvements in methods of and means for delivering substances in a fine or loose state of division or of the nature of flour and the like. 15.7.20.

This application relates to the delivery from bins or storage bunkers of materials in a powdered or a loose state, such as flour and ground cereals generally, and substances in a loose state such as coal, lime, sawdust and the like.

The aim is to obtain a continuous and uniform delivery from the bin by preventing the formation of cores and the periodic sticking and rushing of the material to be discharged.

780.20. Franz Uhlig. Improvements relating to means for closing and opening skips. 16.7.20.

This application refers to self-opening and closing buckets as used with "grab" dredgers, and with certain types of coal and ore handling plant, and describes a bucket made in halves suitably hinged, opening centrally

The operating mechanism consists of rope or chain working over pulleys, and a special form of tensioning and releasing gear.

795.20. F. Seymour. Improvements in furnace and process of combustion of pulverulent fuel. 22.7.20.

This application relates to a type of water-cooled combustion chamber for the burning of pulverised coal at very high temperatures.

809.20. H. A. Symes and V. G. Symes. Improved collapsible wire runners. 26.7.20.

This application refers to improvements in apparatus for the erection of fencing, telegraph or telephone wires, and consists essentially of a portable stand of special design adapted to receive a coil of wire and allow the coil to revolve freely as the wire is paid out.

820.20. C. C. Bussey. Improvements in methods of and apparatus for testing carbonaceous material. 29.7.20.

The method described in this application is that of continuous carbonisation at a moderate temperature, the aim being to obtain a high percentage of the light oils and ammoniacal products rather than the heavy oils of a tarry nature, but at the same time to produce a dense coke.

The apparatus used is a vertical retort, which is internally heated only from the charge itself, otherwise the arrangements are similar to the usual vertical retort practice as regards charging hopper, shape of retort and discharging grate, but the coke is given an extra pressure when still red hot, and is cooled by means of a water-jacketted chamber.

Changes of Address

Adler, H. W., *l/o* City and Suburban G.M. & Estate Co., Ltd.; Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland.

Bell, H. G. F., *l/o* Nourse Mines, Denver; 130, Woburn Avenue, Benoni.

Boydell, H. C., *l/o* Cambridge, Mass.; 1, Metropole Street, Athens, Greece.

Cameron, L. D., *l/o* Rayfield Tin Fields, Nigeria; 34, Prince Albert Road, Mosman, New South Wales.

Cullen, Wm., *l/o* Salisbury House, London; 63, St. Mary's Mansions, Paddington, London, W.C. 2.

Gilbert, T. W., *l/o* North Randfontein G.M.; Langlaagte Estate & G.M. Co., Ltd., P.O. Box 98, Langlaagte.

John, W. E., *l/o* Richmond, Surrey; 120, Victoria Street, Westminster, London, S.W. 1.

New, W. S., *l/o* Randfontein; P.O. Box 1, Knights.

Pam, Lt-Col. E., O.B.E., *l/o* Geldenhuis Deep; Modderfontein East, Ltd., P.O. Box 14, Springs.

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OF THE

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OF SOUTH AFRICA.

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Proceedings
AT
Ordinary General Meeting, 19th February, 1921.

The Ordinary General Meeting of the Society was held in the Assembly Hall, Scientific and Technical Club, 100, Fox Street, Johannesburg, on Saturday, 21st February, 1921, at 8 p.m., Mr. James Chilton (President) in the chair. There were also present:—

24 members: Messrs. F. Wartenweiler, Prof. G. A. Watermeyer, H. R. Adam, C. J. Gray, J. Hayward Johnson, A. King, J. J. R. Smythe, J. Watson, E. M. Weston, A. Whitby, H. A. White, Dr. W. A. Caldecott, A. F. Crosse. Prof. J. A. Wilkinson (*Members of Council*), W. Allen, T. N. Dewar, H. L. V. Durell, K. W. Leinberger, F. Mills, T. Proberts, W. E. Thorpe, T. G. Trevor, J. T Triggs and H. R. S. Wilkes.

2 Associates: Messrs. J. A. Boyd and S. Evans.

6 Visitors and H. A. G. Jeffreys (Secretary).

The President: Ladies and Gentlemen,— At the beginning of this meeting I desire to express the feeling of pleasure which we all must experience in meeting for the first time in our new building. In the search for a local habitation and a home, the Society had many wanderings. It was, I believe, born in a tin shanty on Von Brandis Square, and at that interesting event our friend Mr. Andrew Crosse, who is with us to-night, played a very interesting part. The first meetings of the Society, I believe, were held in the old Chamber of Mines Building in Sauer Street. After that, when the new building was erected in Market Street our meetings were changed to the new edifice. One or two meetings of the Society were held in the Freemasons' Hall in Jeppe Street. From the Chamber of Mines we moved to the University College, and now we have come to what I hope is our final resting place. Our meetings can be held now under our own vine and fig tree, and, on behalf of the Council, I desire to give every member a cordial "Welcome home."

Not one of the least things of interest in this home-coming is the fact that a permanent place has been found for the Memorial which this Society caused to be erected to the memory of its members who fell in the Anglo-Boer War. This Tablet, which bears the names of members who fell on both sides, shows that when necessity arises, our members can drop the test tube and pick up the rifle. Recent events have shown that ancient spirit is not dead; and I hope before long a similar Tablet will be erected to the memory of our members who fell in the last Great War.

We hope that this house will be hallowed by the sacred memories of the past as well as consecrated with great hopes for the future. (Loud applause.)

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 20th November, 1920, as recorded in the November *Journal*, were confirmed.

NEW MEMBERS.

Messrs. F. Wartenweiler and A. King having been elected as scrutineers in connection with the ballot for the election of new members, the following were declared unanimously elected:—

ALLEN, WILLIAM, Crown Mines, Ltd., Johannesburg. Mining Engineer.

HILL, SIDNEY B. N., Breyten Collieries, Ltd., Breyten. Mine Manager

RUNCIMAN, ALEXANDER WALTER, Crown Mines, Ltd., Johannesburg. Mining Engineer.

SCHLESINGER, BRUNO, P.O. Box 7418, Johannesburg. Mining Engineer.

UNGER, FRANK ANTHONY, P O. Box 1048, Johannesburg. Mining Engineer.

WARD, WILLIAM GEOFFREY, P O Box 668, Johannesburg. Patent Agent.

General Business.

THE SOCIETY'S PROGRESS.

Mr. Andrew F. Crosse *(Past President)*: Under "General Business" I should like to make a couple of remarks. The first one is with reference to the past. We started a Chemical, Metallurgical and Mining Society in the old days before this present Society was in existence, but it did not last very long. Then we started this Society, which was a success. I would like to mention the name of one gentleman who did more to keep the boat afloat when we ran on the rocks than anybody else—that was Mr. Sidney Pearce; he deserves the thanks of the Society. It was a great many years ago now; many of you were not members of the Society then; he carried on the work when we had one or two defaulting Secretaries; he launched us into clear water out at sea, and we have been prosperous ever since. I thought I would just like to mention this fact.

Mr. Andrew F. Crosse *(Past President)*: I have now to refer to quite a different subject. For the last few weeks I have been engaged in the most interesting work I have ever had to do since I have been in the Transvaal—nearly 32 years.

A RICH NICKEL ORE.

I am going to bring to your notice this evening one of the most interesting mineralogical discoveries of recent years in the Transvaal. It is an extraordinarily rich nickel ore, and I can find no description in Dana's Mineralogy or in a book—"The Nickel Deposits of the World"—published by order of the Legislative Assembly of Ontario (1917). I want you to look at some pieces of the ore, and also a bar of nickeliferous iron which I have here; it is probably the richest nickel alloy ever smelted direct from the ore, assaying about 52% nickel.

The analysis of a large sample of 76 lbs. was as follows:—

Oxide of Nickel	40·30
Oxide of Iron	49·30
Phosphorus	0·13
Calcium Oxide	0·20
Silica	6·50
Loss on ignition, chiefly water	2·15
Loss	1·45
	100·00

Metallic Nickel	29·6%
Metallic Iron	35·7%
Platinum	0·2 dwt. per ton.

As there is no arsenic or sulphur in this ore it should prove very valuable for alloying with steel; 70% of the nickel produced today is used for that purpose.

I do not think that all the ore will be as rich as this sample, but it will be easy to concentrate either by a Wilfley table or magnetic separator, or the two combined; the specific gravity of this ore is 4·6.

This ore is as far as I am able to judge a new and undescribed mineral. If this should prove to be the case, I should like to call it "Trevorite," after Major T. G. Trevor, Mining Inspector for the Pretoria District, including Barberton.

My thanks are due to Mr. Cottrell, Chief Assayer of the Standard Bank, for smelting the ore according to my instructions as regards flux.

I must not forget to mention where the new discovery of nickel ore comes from; it has been found close to the talc mines on the farm "Bon Accord," north of the branch line to Barberton, near the Sheba siding.

An article on this ore, by Major T. G. Trevor, appeared in the *South African Journal of Industries*, June, 1920.

Major T. G. Trevor *(Member)*: "I am sorry that I came unprepared with notes on this question, but I happened to be in Johannesburg and to meet Mr. Crosse who thought it might be of interest to members if I said something on the subject which he has just mentioned.

"In June last year I was informed that ore carrying about 27% nickel had been found in the Barberton district. I warned the people who told me about it to be careful as there was probably a mistake. I went up and saw the deposit. When I was looking at it I said, do not say anything about it because, personally, I do not think it is nickel—wait until I get some check assays made.' I sampled the occurrence and found the check assays confirmed the original report.

"The deposit occurs on the Lily line in the Jamestown Series just opposite the Sheba Bridge. This line has been thoroughly described by Dr. Hall in his published memoir on 'the Geology of the Barberton Gold Fields.' A bar of hard quartzite forms the ridge pole of a long line of hills. This line stretches for about 10 miles, making a distinct feature of the country for

quite 20 miles. On the top of one of the hills in the ridge a man shot a buck and picked up a stone with which to despatch it. The stone was so heavy that he took particular notice of it, and took it to the camp. That was how the actual discovery was made.

"The richest portion of the ore appears as a massive black rock composed of grains of magnetite closely cemented together, with a slight green tinge, but without any banded structure. Mr. Crosse has given you the analysis of it. When I saw it the deposit was opened up by an open cut about 12 ft. deep. I published a report on it in the *Journal of Industries* for June, 1920.

"The hanging wall was a very fissile sandstone, which a geologist would describe as a 'phyllite.' The reef or deposit was 2 ft. 3 in. wide, and a representative sample taken 3 ft. below the surface gave an analysis of 17·2 %, while a similar sample taken over 1 ft. 3 in. of the foot wall gave 1·67 %. The dip was approximately vertical.

"Since my visit an adit has been put in which has struck the reef, and the reef is now being driven on. Assays vary from 3% to 27%.

"It was at once obvious that this ore was something entirely different from anything of which we had record, so I sent several samples to England. On the main sample sent to the Imperial Mineral Resources Bureau I have not had a report, but from other sources I learn that the ore, owing to the entire absence of sulphur in it, would be of great value to smelt with sulphurous ores.

"As to the quantities in which this ore occurs it is at present premature to say anything except that you have a definite outcrop for about 300 ft., assaying anything from 3% to 27%; also that on the same line, 1,500 yds. to the east the talc deposits everywhere contain traces of nickel. In the main talc mine there are pieces of honeycombed limonite, which are so porous that they will float on water for quite a considerable time before sinking. I had some of this assayed by Dr. Moir, and it gave a result of 2·7 % nickel. It is, therefore, obvious that there is a very considerable area in this locality which is impregnated with nickel and that the prospects of it developing into an important nickel mine appear to be extremely good.

"I must thank Mr. Crosse for the unexpected compliment he has paid me with regard to the name, which I accept. It is not particularly euphonious, but that is not his fault."

Mr. Andrew F. Crosse (*Past President*): I would like to make one more remark while we are on this subject. In smelting this nickel ore the largest proportion of the material I used for the flux was the talc itself. So that, if the talc contained nickel, that would go out into the metal. That is rather interesting.

Mr. H. R. Adam (*Member of Council*): I think you stated this was an alloy of nickel.

Mr. Andrew F. Crosse (*Past President*): It is an alloy of iron and nickel. There is graphite in it, of course, as in everything that is run down with carbon. There is iron with the nickel, but as the alloy will be required to mix with steel for making rails and various other things (French engineers recommend 3% of nickel in the steel rails for railways) you have no refining; no refining is necessary. You simply throw it in and average the percentage, just as the wine merchant does when he puts alcohol into wine.

The President: I think we are very much obliged to Mr. Crosse for bringing before us this occurence of a mineral which promises to be of industrial importance.

FIRE-DAMP IN THE GOLD MINES OF THE FAR EAST RAND.

By T. N. Dewar (*Member*).

During the past few years trouble has been experienced in certain mines of the Far East Rand through occurrences of fire-damp.

Fire-damp being generally associated with collieries, created some surprise when it made its appearance on the gold mines.

Coal beds and gold bearing reefs are mined in the Far East Rand area, the vertical distance apart being about 4,000 ft.

The collieries are singularly free from fire-damp and the death roll from explosions can be almost entirely credited to the gold mines.

As the subject is one of considerable interest the writer will describe each occurrence of fire-damp in detail and afterwards summarise the position.

The Brakpan, Government G.M. Areas and Daggafontein mines have had difficulties through occurrences of fire-damp.

Brakpan Mines.—In the Brakpan Mines, No. 2 Shaft, the first accident happened on the 19th March, 1913. The No. 8 West Winze dipped at an angle of 15° to 20° for 270 feet, and then rose gently for 130 feet. Two small dykes were passed through, one on the slope and the other up the rise. A fissure was encountered at the face from which a large quantity of water issued, and the winze became partly flooded. A pump was installed to handle the water. In due course the water level fell suddenly so a pumpman went down to ascertain the cause and found the water had fallen about 4 in. from the hanging in the hollow. On holding his lamp up to make the inspection, an explosion occurred and he sustained fatal injuries. Later on it was ascertained by tests that the gas issuing from the fissure was fire-damp. Nobody suspected the occurrence at the time, and it first made its presence felt by the accident. It is obvious that the gas had accumulated behind the water in the hollow and was released by the lowering of the water level by the pump. The depth from the surface to the face of the winze was about 3,470 feet.

On the 26th August, 1915, fire-damp was met with in a different part of the same mine. In going through with a cross-cut in the 17 East Level an upthrow fault with a 70-foot throw was encountered. It was intended to put up a boxhole from the 17th to the 16th Levels, so a raise 9 feet by 7 feet was started at a slope of 30° and struck the fault at about 30 feet up. Continuing through the footwall shales at an angle of 60°, the raise reached a length of about 120 feet. A slight trace of fire-damp had been met with on the 13th July, 1915, and a native burnt, so ventilation had been provided for by 6 in. galvanised iron piping and a fan. Despite this, more gas came off and an accident happened as stated on the 26th August, 1915, whereby the trammer and a native were seriously burnt, the latter succumbing to his injuries. Apart from the fault there was no fissuring in the shales and the place was dry. The depth from the surface to the scene of the accident was a little over 4,000 feet.

In February, 1919, a round was being drilled over in the 17 A West Winze, which was going down on the reef at a slope of 4°. The miner heard a slight hissing sound in one of the top back holes. He applied a light and the issuing gas burned. The hole was plugged and tested again in the presence of the shift boss. On removing the plug the gas lit and burned with a long blue flame. It was proved later that the fire-damp was coming off a fault. The depth from the surface to this working place was about 4,100 feet.

The 17A West Winze was driven off the 16 West Haulage, and the haulage itself was the scene of an accident on the 17th of February, 1920. The 16 West Haulage dips at an angle of 15° for about 900 ft. At this point the reef was struck and 17A East and West Drives turned off. The haulage was continued in reef for about 200 feet when an upthrow fault was met with. Two dykes were passed through and the haulage continued in footwall shales. It rose for about 350 feet at 8°. Several fissures were met with, and a little water came off smelling of sulphuretted hydrogen. In the face a round was being drilled, and gas came off a top back hole. The miner knew nothing of it till he lifted a lamp to light his pipe. There was a severe explosion, the miner and four natives being seriously burnt. Three of the natives died soon after. The place was rather warm so they had been working more or less naked; consequently the burning was very severe. The miner had his shirt open, and was badly burned about the neck and arms. Subsequent tests showed a cap on a safety lamp indicating fire-damp to be present. The haulage was continued under certain restrictions with safety lamps without further incident till it holed with the South-West Incline.

In November, 1920, the 18 West Haulage going into the same area encountered fire-damp. In this case no fault was struck, and the haulage was driven on a rising grade of 1 in 100. As the reef rose on a steeper angle footwall shales were entered. Driving was continued a long way and a saddle-back of white quartz was passed through. On the other side gas was found, but safety lamps being in use there were no casualties. The fire-damp issuing from a top back hole was lit and burned with a flame about 2 feet long for some time. The method adopted to avoid danger in this working place was to establish a lamp station about 400 feet from the face where naked lights were left. The face was examined frequently with a

safety lamp while drilling operations were in progress. A cable was carried forward close to the face and a cluster of electric lights provided the necessary illumination for the work going on. Several pockets of fire-damp have since been passed through but the precautions taken have prevented any trouble. The face of the 18 West Haulage is about 4,200 feet below the surface.

Four out of the five occurrences of fire-damp in the Brakpan Mines are in the neighbourhood of a dyke which traverses the west side of the property. The dyke splits up in places into three sections and has been traced over a distance of 4,000 yards. The other place, 17E Raise, is 500 yards east of the dyke, but is probably connected to it by the line of faulting which was passed through in the raise as described.

Government Gold Mining Areas.

On the 28th of August, 1915, an accident happened at the North West Shaft of the Government Gold Mining Areas which may be classed as an occurrence of fire-damp. The shaft had gone through the reef and was continued in footwall shales for about 200 feet. Accumulations of ground caused by spillage when loading from the shaft boxes made it desirable to put in a cross-cut from the 11th Level. This cross-cut was driven in footwall shales and holed with the shaft bottom on the day in question. The miner and the shift boss went in to inspect the place after blasting through. On their way in an explosion occurred, and they were burnt slightly. At the time it was thought the gas had come from the mass of broken ground in the shaft bottom, but in view of the later occurrences it is likely that fire-damp was present. The depth from the surface was about 2,400 feet.

In the beginning of March, 1916, a genuine pocket of fire-damp was met with in a boxhole going up from a footwall cross-cut 3,000 feet north of the South-East Shaft in a line with the North-East Shaft. Gas was ignited which fortunately caused no casualties. The depth from the surface was about 3,400 feet, and there is no faulting in the immediate neighbourhood.

A boxhole off the South cross-cut from the South-West Shaft was the scene of a fatal accident on the 2nd May, 1918. The boxhole was going through footwall shales and was on a grade of 50°. A blower of fire-damp was ignited when the place was 50 feet up. Two natives were burnt, one fatally. The pocket of gas burned for about 12 hours. There was no water issuing anywhere in the boxhole, which was situated at a depth of about 3,700 feet from the surface. It was close to a large dyke which traverses the south side of the property which has been traced for over 5,000 yards.

Reviewing the three occurrences of fire-damp at the Government Gold Mining Areas, it is of interest to observe that all are in independent sections of the mine, and in one case only can a connection be readily traced to faults or dykes.

All the foregoing occurrences can be grouped in a rectangle of 5,000 yards by 2,000 yards. The next series is situated in a different part of the field at Daggafontein. The distance between tne two areas is about 13,000 yards, and the latter group are enclosed in a rectangle of 1,100 yards by 500 yards.

Daggafontein.—The No. 1 Shaft, Daggafontein, is 3,650 feet deep. The North haulage was driven on a slight dip for several hundred feet, and then started to rise gently. On the 16th March, 1917, a fissure was struck, giving off large quantities of water under great pressure. The water accumulated in the dip as in the case of the No. 8 West Winze at Brakpan. A pump was set to work and reduced the water level sufficiently for a shift boss to venture through. An explosion occurred and the unfortunate man was fatally burnt. Tests next morning showed a large cap on a safety lamp when held a short distance beyond the dip. A one-inch pipe was inserted into the drill hole from which gas and water was escaping. The pipe was then plugged. Fully three years later it was found that an undue amount of water was coming out of the haulage and a shift boss proceeded in to make enquiry. He was fatally burnt by an explosion which followed. It was found later that the plug had blown out of the pipe, thus permitting water and gas to escape freely.

On the 31st December, 1917, a strong feeder of gas and water was struck at the face of the West Haulage No. 2 South Drive. The West Haulage dips from the shaft station on a slope of 5° for 1,260 feet. At this point the No. 2 North and South Drives were turned off. The latter went flat for about 80 feet and then rose for 150 feet at 8°. The outburst of water was so great that the mine was flooded, and the water rose 1,000 feet in the vertical shaft. During the subsequent pumping operations,

bubbles of gas were constantly coming out of the delivery pipe in gushes. The bubbles could be lit easily. About December, 1918, the No. 2 South Drive was entered again, and a temporary dam put in with several pipes to keep the water pressure off till the dam was set. It was intended to apply the cementation process. 5,000 gallons of water leaked past the dam every hour, and the pressure stood at 450 lbs. per square inch. In making enquiries after a fatal accident had occurred there on the 31st January, 1919, two men having been burnt, the writer calculated the gas was making at the rate of 190 cubic feet per hour. There was a strong smell of sulphuretted hydrogen at the spot. In the No. 3 South and No. 4 South Drives fire-damp was found bubbling up from the footwall on a fault plane crossing both drives. In all the occurrences the depth from the surface is about 3,700 feet to 3,800 feet.

Taking the four points in Daggafontein into review it is found they lie in a zone between two parallel dykes 500 yards apart. The gas occurs in three cases on cross faults from dyke to dyke, the other being on the northern dyke itself.

Composition of Fire Damp.

A sample of the fire-damp taken on the 7th November, 1918, at Daggafontein, gave the following composition :—

Methane	23·4%
Hydrogen	3·0%
Oxygen	10·0%
Carbon Dioxide	Trace.
Balance presumably Nitrogen ...	63·5%

Carbon monoxide and sulphuretted hydrogen were practically absent.

Looking over the compositions of fire-damp found in the coal mines as quoted in R. A. S. Redmayne's "Ventilation of Mines," it would appear that the above gas does not correspond well with the usual fire-damp. For instance, a typical blower at Hebburn Colliery gave—

Methane	78·8%
Oxygen	1·7%
Carbon Dioxide	0·9%
Nitrogen	18·6%

A composite analysis taken from six different sources by the Austrian Fire-damp Commission gave—

Methane	89·76%
Hydrogen	0·23%
Oxygen	0·39%
Carbon Dioxide	1·98%
Nitrogen	7·14%

The Jarrow 5-seam, according to Beche and Playfair, gave off fire-damp with a hydrogen percentage corresponding to that of Daggafontein :—

Methane	79·7%
Hydrogen	3·0%
Oxygen	3·0%
Carbon Dioxide	2·0%
Nitrogen	14·3%

The Prussian Fire-damp Commission records a blower at the Consolidated Colliery, Schalke, where the gas was collected in a pipe and used for lighting the heapstead. The percentage of hydrogen is greater than that quoted above.

Methane	89·88%
Hydrogen	5·84%
Carbon Dioxide	0·67%
Oxygen and Nitrogen	3·61%

All the above examples are taken from Redmayne's "Ventilation in Mines."

In testing the fire-damp at Daggafontein No. 2 South Drive the writer found it caught the flame of the safety lamp very quickly. A slight cap showed on a lamp being moved slowly upwards and with a small travel of the lamp the flame was extinguished. Some time ago fire-damp was found at the Largo Colliery, north east of Springs, and the writer was informed by the Manager that the gas there was also very quick. Perhaps the high percentage of hydrogen may account for it. According to the volume on "Ventilation," issued by the International Correspondence Schools, the ignition points of methane and hydrogen are 1202° F. and 1080° F. respectively. It is also stated "that a peculiarity in the ignition of marsh gas (methane) is that the temperature must be maintained at or above the temperature of ignition of the gas for a certain period of time before the ignition of the gas will take place. This time although but a fraction of a second is of the utmost importance in mining, since it renders possible the use of many detonating explosives without fear of ignition of the gas."

The writer suggests that possibly the high percentage of hydrogen may account for the sensitive nature of the flame of the safety lamp when testing for this fire-damp. It is hoped that further analyses and tests may be available later to show if there is anything in this point.

The next question that arises is to account for the presence of the fire-damp in these metalliferous mines.

Geology.

Looking at the geology of the country in the neighbourhood of the mines mentioned, it is found that basins of coal-bearing karroo rocks overlie the dolomites which in turn overlie the Witwatersrand series.

In several of the shafts the dreaded " Green Dyke " is found, a dolerite sheet which weathers and gives great trouble with pressure on the timbers. It occurs in the No. 1 and No. 3 Shafts, Springs Mines, No. 1 and No. 2 Shafts, Daggafontein, and attains its greatest thickness of 95 feet in the South Shaft of the New State Areas. A syenite sheet split up into several sections appears in most of the shafts in the south and east of the Far East Rand. At No. 2 Shaft, Springs Mines, it totals 220 feet in two sections. Interbedded in places with the syenite sheet is the dolomite, which attains its greatest development in four sections at Daggafontein No. 1 Shaft, where it has a thickness of 436 feet.

The coal measures are in the form of basins of very varying thickness. Taking an average of eleven shafts situated in Brakpan, Government Gold Mining Areas, New State Areas, Springs and Daggafontein, the average thickness to the base of the Dwyka conglomerate is 148 feet. In this area the coal seams average 19 feet in thickness, and attain their greatest development in a line running south and east of the gold mines. The seams have been or are being worked at Apex, Brakpan, Rand Colliery, Schapenrust and De Rietfontein, a belt of 13,000 yards long. Brakpan Colliery worked over the present Brakpan Mines, but the other collieries have no gold mining going on at present underneath them. At De Rietfontein Colliery, when it was working, bubbles of fire-damp were sometimes found issuing from the footwall. Though the coal measures are well developed in the three shafts of the Springs Mines no fire-damp has been found in that mine which will probably in time work under the abandoned De Rietfontein Colliery. Taking the three mines particularly concerned in this paper, the Brakpan No. 2 Shaft has a 14-foot seam of coal in the 144 feet of karroo rocks. The Government Gold Mining Areas, South East Shaft has no coal in 90 feet of sandstones. The Daggafontein No. 1 Shaft showed no coal in 72 feet of sandstones, but the No. 2 Shaft, 2,000 yards to the west, had 50 feet of inferior coal in 175 feet of measures. The surface elevations show that the coal has been denuded at No. 1 Shaft near by the Blesbok Spruit. At the Largo Colliery, where a little fire-damp was found recently, the development of the coal measures is typical. Three seams of coal are met with, totalling 34 feet in a thickness of 193 feet. Gas has only been met with in the lower seam, which has a thickness of about 10 feet. It is overlaid by a dense close-grained shale of about 8 feet. All the strata above this dense shale are porous, and no gas is found in the two upper seams. The lower seam referred to overlies 3 feet of Dwyka shales which rest on the Dwyka conglomerate.

Conclusions.

It is noticeable from the occurrences described that the fire-damp in the mines of the Far East Rand is found principally in the presence of upthrow faults which bring the footwall shales into position for driving through. In the majority of cases faulting and water seem necessary for the presence of gas. In some cases sulphuretted hydrogen accompanies the fire-damp, but not always so. It is assumed by many people that the gas travels with the water down fault planes from the coal measures. The great problem is to account for the vertical movement of the gas of nearly 4,000 feet.

In the Apex Old Colliery a little fault came through on the east side of the shaft. This was about 1896, and a good supply of water came off the fault. A sump was made and an electric pump installed to raise the water to the surface for boiler and domestic use. The workings of the colliery steadily progressed away from that area, and the supply remained undiminished. Some water overflowed into the abandoned workings near the shaft and remained there for years. About 1906 the Brakpan Mines began to develop from the No. 2 Shaft 1,500 yards distant. As the drives came forward towards the Apex, the spring suddenly disappeared, and the water in the workings followed suit. It would, therefore, appear that in places there is a definite conneceton through faulting from the coal measures to the gold measures. The dolomites form a very convenient water channel all over the area. They are jointed and large quantities of water lie in the crevices. For instance, during cementation work at Brakpan No. 3 Shaft, small plates of cement were found in sinking

through the dolomite in the South Shaft of the New State Areas 3,300 yards away.

The difficulty is just why fire-damp should not take the line of least resistance and escape up the faults to the surface, instead of travelling down them. The fact remains that fire-damp is generally found in mines where the coal measures are developed above or where a connection with them is available through the dolomites for gas to travel.

On the other hand it is to be noticed that the gas is usually found actually in or about the footwall shales which are very jointed. Carbon is also found occasionally on the contact of the reef and the shale where, especially if associated with pyrites, a great enrichment of values takes place. Perhaps under heat and pressure some reaction may take place between the pyrites, water and carbon in or under the shales to produce something in the shape of fire-damp.

Redmayne, in the "Ventilation of Mines," states "that a blower of fire-damp has occurred from time to time in the famous Van Lead Mine, near Llanidloes, in Montgomeryshire, the vein of which traverses rocks of the lower silurian age. It is difficult to account for the presence of fire-damp at this mine as there are no carboniferous rocks in the neighbourhood and decaying timber could not account for the existence of a blower of gas. Possibly it owes its origin to the decay of plant or animal life of the silurian period, and has been pent up through the succeeding ages, or it may be due to the chemical action of acidulated waters or mineral substances. It is a peculiar feature of the emissions at this mine that they are accompanied by sulphuretted hydrogen."

A fine opportunity presents itself to the chemical members of this Society to elaborate a hypothesis on the basis of the above with special reference to the conditions prevailing in the Far East Rand Gold Mines.

The difficulty in connection with occurrences of fire-damp in metalliferous mines is the fact that very few of the men working there have any knowledge of fire-damp. It constitutes a danger when it comes in contact with people who have not even heard of it. Its presence is often first announced by fatal burning accidents. In these deep mines the temperature of the workings is generally fairly high, about 75° to 85°. European and natives alike work with a minimum of clothing, and when an accident happens, the burning is severe owing to the amount of skin exposed.

When a zone of fire-damp is met with the first problem is where to begin precautions, for often one does not suspect the presence of gas until an accident occurs. An equal difficulty arises as to where one should end these special restrictions. To work these mines under the regulations applicable to fiery mines is not practicable or reasonable. Yet the same thing occurs in Scotland in the so-called non-fiery mines where the use of naked lights is permitted. It is found that the proportion of accidents due to fire-damp is greater than in mines where fire-damp is known to exist and where the work is organised and discipline maintained on a fiery mine basis.

New shafts are being sunk at Brakpan Nos. 3 and 4, New State Areas, North and South, West Springs Nos. 1 and 2, all in or about the locality where coal measures are known to exist. It is possible that further occurrences of fire-damp may be found. The objects of this paper have been to place on record such occurrences as have been known in the Far East Rand and to raise criticism and discussion. The subject is of special importance to the people concerned in these happenings, which generally mean lives lost and if the discussion evoked makes for safety the paper will have served a humane purpose.

Mr. C. J. Gray (*Member of Council*): I have listened with great interest to Mr. Dewar's descriptions of the occurrences of fire-damp on the Far East Rand. There have been rare occurrences elsewhere on the Rand, but they have not come within my own personal experience. Mr. Dewar is perhaps right in thinking that the fire-damp comes from the overlying coal measures. In consideration of the way in which fire-damp travels I have never heard the solubility of fire-damp taken into account. It appears to me quite possible that water will dissolve a certain quantity of fire-damp and will carry it as it travels through the rocks. I cannot imagine fire-damp travelling downwards through water-saturated rocks, except as a solution in the water. In most of these occurrences it appears that water was actually issuing along the fault plane or fissure. In those cases the release of pressure might allow the fire-damp which was dissolved to issue. Even although no water was actually coming out with the fire-damp it still is possible that water previously had held it, because fire-damp might travel some distance through fissures and cracks away

from the water from which it had been released. Apart from the idea that the fire-damp has come from a higher level, there is the possibility that it has been generated, as Mr. Dewar suggests, from carbonaceous material in the rocks in which the reef is embedded. Recent thought and observation have led to the opinion that oil is almost always produced from carbonaceous material in rocks; the old idea that it might be of deep-seated origin seems to be losing ground. Many of those rocks from which crude oil issues have been found to contain very small proportions of carbonaceous material; yet it is argued that the oil has come from that material. If oil in commercial quantities can originate in rocks containing a small amount of carbon, it seems easy to believe that fire-damp in considerable quantities may do so; and a large quantity of fire-damp would weigh very little in comparison with a few quarts of oil. It is of the first importance in considering such a theory to know the composition of the gas. Mr. Dewar has been able to give only one analysis of the fire-damp or gas found, and there is some difficulty in deciding that it represents the character of the gas generally. It appears to me, looking roughly at the composition given, that it represents a mixture of fire-damp with air. The percentage of nitrogen is high, but in a paper read before the Society some time ago, I dealt with the occurrence of nitrogen in raises. Most of the fire-damp occurrences were in raises, and perhaps some of the oxygen of the intermixed air has been lost by the action of pyrites or otherwise.

Mr. Dewar has mentioned the quickness of action of this fire-damp when tested with the lamp; he says that the first test near the floor shows nothing in the lamp, but with a very slight upward movement the lamp goes out. I do not know whether Mr. Dewar has fully taken into account the behaviour of fire-damp in a still place. Commonly in a colliery, when you test for fire-damp, you have a considerable amount of air motion, and you get intermixture of fire damp with the air. In such a case you get a gradual transition, from comparatively pure air containing a small amount to air which contains so much fire-damp that it explodes in the lamp. In between you get caps of various lengths. In an absolutely still place—a place where there is no air current, a very quick transition is found by the lamp. Some years ago, after the Glencoe Colliery explosion, we wished to recover the bodies of those of the search party who lost their lives; we were not quite certain that if air reached the scene of the fire at the end of the heading it would not cause another explosion; and we therefore had to be exceedingly careful in restoring ventilation to a sufficient extent to permit us to reach the party. We caused the air to advance by closing the door between the upcast and downcast shafts; we closed the door very gradually so as to let the air creep forward, and in that case we found a very marked contact between the fire damp and the air; one could almost draw a curve showing how the fire-damp came down in the drives. It first came down very gradually, and then quickly. Diffusion is a very slow phenomenon indeed. If you have an issue of fire-damp in a mine there is marked stratification; the fire-damp and air behave as though they were separate liquids which do not mix very easily. So, in a still place, within a few inches or a foot you can get air which shows practically nothing in the lamp and then fire-damp which explodes in the lamp. I am therefore not certain that the sharp action referred to by Mr. Dewar proves that the fire-damp differs from the ordinary fire-damp met with, say, in the collieries in Natal.

Mr. Dewar referred to the question of accidents. He need not have gone so far as the non-fiery collieries in Scotland to show that the majority of accidents occur where fire-damp is generally unknown. My experience in Natal was that the greater number of fire-damp explosions occurred in collieries in which usually you could find no fire-damp. In those collieries people got careless and assumed they would not get fire-damp.

I thank Mr. Dewar for his very interesting remarks, and I propose a very hearty vote of thanks to him for them.

Major T. G. Trevor (*Member*): " As it is unlikely I shall be here when further discussion takes place I should like to call Mr. Dewar's attention to the analysis of a blower of gas which occurs on the farm Gruisfontein, No. 48, near Devon Station. In the year 1910 they were putting down a borehole for water on this farm, which is approximately 36 miles east of the mines Mr. Dewar was speaking of, and it passed through something like 160 ft. of igneous rock and then got into the coal measures and sandstones. The search for water did not proceed any further, but at 540 ft. a very strong blower of gas was encountered. The borehole was inspected in August, 1910.

There was a pressure of about 60 lbs. to the square inch. I visited it at that time with Dr. Mellor and again in 1914 with Mr. Cunningham Craig.

"An analysis of the gas, which is given in the Government Mining Engineer's Report for 1910, shows 38% of hydrogen. This was so extraordinary that I took out Mr. Cunningham Craig, who came out to report on the oil prospects in South Africa in 1912-13. He talks in his report of the curious composition of this gas, which contained upwards of 38% hydrogen. I think if Mr. Dewar refers to that report he will find it interesting as throwing light on the origin of the gases which he has been dealing with.

"Regarding the gas occurrences at the Van Mines in Wales, I can confirm Mr. Dewar's reference as I worked on that mine as a youth, and was burnt by the gas in question."

Prof. G. A. Watermeyer (*Vice-President*): We ought to thank Mr. Dewar for the extremely interesting paper he has given us. We are very much indebted to him for placing these facts on record: they will be valuable for future reference. Regarding his theories on the source of the fire-damp, I scarcely think that the origin from the coal measures nearer the surface tenable. The solubility of fire-damp in water is not very great, and as the water percolated downwards, the increase of pressure would tend to drive out the gases in solution.

I prefer the more obvious explanation that the marsh gas is generated by the action of damp on carbon already existing in the layers at great depth. On the Van Ryn there is a layer of rock called the carbon leader which is fairly persistent, and we know that diamonds have been found occasionally in mortar boxes on the Far East Rand.

THE GOLD PREMIUM.

By S. Evans (*Associate*).

(*Printed in the Journal, May, 1920.*)

REPLY TO DISCUSSION.

As far as the discussion of my paper is concerned, there does not appear to be much in the way of reply called for, unless I go over ground which I have already covered or which has been covered by Professors Cannan, Leslie and others. There are, however, a few considerations which I should like to submit to you on this occasion, and which have occurred to me as the result of the perusal, not only of the discussion here, but also of the Report of the House of Assembly Select Committee on Embargo on Export of Specie and of the debate in the Union Parliament on the Currency and Banking Bill. I do not propose to attempt a detailed criticism of the Select Committee's Report. That has been very ably done by Professor Cannan, both in his contribution to our discussion, and in the article which appears in the December issue of the *Economic Journal*, the official organ of the Royal Economic Society. Now that the elections are over, I hope some of our papers will re-publish that article, as the monetary problem is going to be a very live issue in this country and in other countries for a great many years to come.

Almost invariably in the controversies on money that have taken place since the beginning of last century, there have been two parties, viz., those who favour sound money, and those who favour something else. The advocates of sound money have been known as bullionists, the currency school, and hard money men, etc., whilst their opponents have been called inflationists, soft money men, greenbackers, etc. I do not say that these designations are always acceptable to the parties concerned. Inflationists usually describe themselves as "Practical men," and their opponents as theorists, doctrinaires, purists, economic pundits, etc. Now, whenever in a currency controversy a man poses as a practical man, you may be quite sure that he is ignorant of the history of monetary discussions, and does not realise that he is in effect telling the world that he is an inflationist. Moreover, in view of the way in which the practical man has been handled by Professors Sumner, Bonamy Price and others, I hardly think that a well-informed partisan of any monetary system, however unsound, would care to damage his case to the extent involved in calling himself a practical man. As Bonamy Price said: "It is a mistake, though a very common one, to suppose that practical men, as they are called, are destitute of theory. The exact reverse of this statement is true. Practical men swarm with theories, none more so. They abound in views, in ideas, in rules which they endow with the pompous authority of experience." Theory is inevitable. "There always has been, and there always will be, theory taking upon itself to guide practice." "One of two

things is absolutely certain to occupy the seat of authority, the theory of the practical man or the theory of the man of science." "The difference which separates the man of science from the man of practice does not consist in the presence of general views and ideas on one side, and their absence on the other. Both have views and ideas. The distinction lies in the method by which those views have been reached, in the breadth and completeness of the investigation pursued, in the rigorous questioning of facts, and the careful digestion of the instruction they contain, in the co-ordination and the logical cohesion of the truths established." Practical and empirical men "have at all times propounded and acted on doctrines of the most elaborate kind"; "doctrines not worked out by careful analysis and accurate reasoning, but roughly gathered from the first crude thoughts suggested by the outward appearance of trade." For a time, about the middle of last century, "the world fondly imagined that the practical man was vanquished and gone; that Adam Smith had finally disposed of him; that boys and students had learnt to pity him, and to pride themselves on having been born after the great Scotch genius. Never was there a greater mistake." The world continues to defer to the practical man, "to great bankers and merchants, to men who have conducted vast businesses, and have realised gigantic fortunes. These men, the world has said, have spent their lives in dealing with money. Must they not know the nature of money and its laws? Must we not take our theory at their hands? And so mankind did take the theory of money from commercial authorities, and the result has been currency in the state in which we now find it." Although these words were uttered in 1869, when the Greenback controversy was in full swing in the United States, they are equally applicable to the state of affairs which exists to-day in South Africa and elsewhere. The present confusion of the currency and exchanges of most European and some other countries is due chiefly to the fact that Governments have acted on the advice of the practical man. Professor W. G. Sumner, in his "History of American Currency," writes that in the debate in the House of Commons on the Report of the Bullion Committee in May, 1811, "the 'theorists' and the 'practical' men found themselves in sharp contrast. The Bullion Committee took the evidence of their witnesses as to fact but gave their own explanation of the facts. They carried the best thinkers in the House with them, but found the practical bankers and city men, and the great mass who did not understand the matter, and who had an invincible dislike to admitting that bank notes were depreciated, against them. In this case, as always, theory and practice are inseparable. The city men had a theory of their facts. It was really one theory against another; the one drawn from a narrow routine; the other a philosophical and scientific generalisation from a broad range of facts. The theorists were beaten, and the nation went on for eight years' further experiment of the paper."

History is constantly repeating itself. In past currency controversies between the practical man and the theorist, the practical man has always been defeated. It is true that often he has won at first, but he has invariably been proved to be wrong in the end, although in many instances it has taken a number of years to reach the end. The practical man, however, is irrepressible, and particularly so in the matter of the currency, largely owing to the fact that on that subject the inclination of most politicians is to ignore the teachings of history. They are like the man to whom the poet refers:

"He must taste for himself the forbidden springs;
He can never take warning from old-fashioned things."

How little his past failures have discredited the practical man is proved by what has happened with the currency of South Africa in the last four years. The practical man is chiefly responsible for what we have done, and has an even greater responsibility for what we have left undone in the matter of the currency.

What has the practical man been teaching us? From 1916 onwards the practical men on the spot, the bankers, have been telling us that it was a wise policy to impose an embargo on the export of gold, to prohibit the melting of gold coins into bullion, and to make paper money inconvertible; that the enlargement of the paper circulation of South Africa from £2,150,000 to several times that amount was necessitated by the world-wide increase in prices, and could not have been avoided, and that it was for the good of South Africa that the banks should go on printing as much paper money as they considered was required to carry on the business of the country. And it must be remembered that during all this time gold con-

tinued to circulate. The natives on the mines were paid entirely in gold up to the middle of December last.

Although the Government followed the advice of the practical man and imposed an embargo on the export of gold, it does not appear that they were altogether satisfied as to the soundness of this policy. In the second half of 1919, after the premium on gold had shown that our currency was depreciated, there was a widespread disposition to question the wisdom of the embargo, and particularly of the action of the banks in flooding South Africa with paper money, with the result that the demand for a free market in gold became rather insistent. On the 22nd and 23rd of October, 1919, a conference, to consider the feasibility and desirability of removing the embargo on the export of gold and establishing natural exchange rates between the Union and the rest of the world, was held in Pretoria. At this conference the four bank representatives were alone in their demand for the maintenance of the embargo "until conditions became normal." A majority, composed of Professor Leslie, Sir Robert Kotzé, Lieut.-Colonel Creswell, Messrs. Jagger, Leisk, Van der Horst and Wilcocks, voted for a motion proposed by Mr. (now Sir) E. Oppenheimer in favour of the establishment of a Mint and Refinery with the utmost despatch, and "that the embargo on the export of specie from the Union be not continued after the establisment of a Mint." This conference also decided unanimously to urge the Government to introduce in the following Session of Parliament a Bill to unify the banking laws of the Union with "stringent provisions against the inflation of the currency." Referring to this conference, General Smuts, speaking at the South African Party Congress held in Pretoria on the 30th of October, 1919, said:—

> "South Africa was the only country in the world where one could go into a bank and get gold in exchange for notes and cheques. The conference advised the Government to continue this gold currency and not to resort to notes. A gold currency was an immense source of strength. The conference was in favour of a free gold market in South Africa, and upon that basis they must build up their industries. The Government agreed with these principles, and would work upon such lines." (*The Star*, Johannesburg, 30th October, 1919.)

It would appear that this attitude on the part of the Government caused some apprehension amongst the bankers, and the General Manager of the National Bank, in a communication published in the *Rand Daily Mail* of 24th January, 1920, stated that, rather than continue the then impossible situation, the banks were even prepared to deposit with the Government a full gold backing for all their notes if the Government made the notes legal tender and inconvertible for the time being. Unfortunately the Government did not remain for long in the frame of mind indicated by the Prime Minister's speech from which I have quoted. Early in January, 1920, there appeared on the scene a superior practical man in the person of Mr. (now Sir) Henry Strakosch. Sir Henry possesses persuasive powers of no mean order, and has a wide knowledge of the technicalities of the exchange market. He was consulted by the Union Government, and he confirmed the advice given by the bankers, namely, that the increase of the paper money from £2,150,000 to over £8,000,000 was not excessive; that additional currency was needed because of the increase of prices; that the increase in prices was attributable to under-production and over-consumption; that it would be a grave mistake to remove the embargo on the export of gold or attempt to fix a date for its removal, and that, in order to protect the reserves of the banks against smugglers and hoarders, gold should be taken out of circulation and replaced by inconvertible paper.

In February, 1920, an Advisory Committee, formed of representatives of the Treasury, the banks and the agricultural, mining, commercial and industrial interests met in Pretoria at the invitation of the Government to consider draft banking and currency bills based on recommendations made to General Smuts by Sir Henry Strakosch at the end of January. I was Chairman of this Committee. The draft bills provided, *inter alia*, for the creation of a new bank, which would centralise reserves and have a monopoly of note-issuing within the Union. They also provided for the discontinuance of the convertibility into coin of paper money whilst the market price of gold in the Union exceeds £3 17s. 10½d. per standard ounce. My attitude in reference to these proposals was this: I agreed with the other members of the Committee that the embargo on the export of specie could not be removed suddenly, and that safeguards would have to be provided against an unduly

rapid deflation. I did not agree with the majority of the Committee as to the note-issuing provisions of the draft bills, as I preferred a fixed limit to the fiduciary issue such as that provided in the Bank Charter Act. I held that the rise in prices in South Africa was due largely to the fact that the banks had quadrupled their note circulation since 1914, and I urged that the draft bills should contain provisions which would make it definitely to the interests of the banks, not only to stop the further inflation of the currency by means of notes, but also to reduce substantially the quantity of paper money in circulation. I also held that there was no necessity for the gold certificate, and favoured making the notes of the banks inconvertible for a definite period not exceeding two years, or pending investigation by a Select Committee, on condition that the banks deposited with the Government gold coin or bullion to the full face value of the notes issued or to be issued in excess of the quantity in circulation when the war commenced, and that the notes issued prior to that date (middle of 1914) and not covered by gold deposited with the Treasury should be subject to a tax of five per cent. No report was made by the Committee, but to avoid misunderstanding as to my view I wrote to the Minister of Finance on the 23rd March, 1920 (Appendix 7). What occurred on this occasion convinced me that for the time being the practical man had definitely gained the ascendency. The change in the attitude of the Government was unfortunate for South Africa. The determined prosecution of the policy initiated at the Pretoria Conference in October, 1919, might have arrested the upward movement of prices early in 1920. The abandonment of that policy has meant another year of inflation and has made the return to an effective gold standard infinitely more difficult. An additional supply of paper money, equal approximately to £1 per head of the white population of South Africa, was issued in the course of the first four months of 1920. During that year substantial increases were made in the salaries and wages of Europeans in the service of the Government, Railways, Municipalities, banks, mines and other industries, with the result that by the end of last year very heavy extra burdens had been imposed on practically all employers of labour, necessitating fresh taxation by the Government and by other public bodies, increased railway rates and higher prices for all goods produced wholly or partially by white labour.

In March, 1920, the House of Assembly appointed a Select Committee under the Chairmanship of Mr. Burton, the Minister of Finance, to enquire and report upon—

(*a*) The effect of the embargo on the export of specie upon the cost of living; and

(*b*) The desirability and practicability or otherwise, with a view to improving the economic conditions of the Union, of removing the embargo and of modifying the statutory provisions at present in force in regard to currency and banking.

At their second sitting the Treasury supplied the members of the Committee with copies of the two draft Currency and Banking Bills, of Sir Henry Strakosch's pamphlet on "The South African Currency and Exchange Problem," and of the record of the proceedings of the Gold Conference held in October, 1919. The Committee heard the evidence of twenty-one witnesses on thirty-one days between 23rd April and 17th June, 1920. Sir Henry Strakosch was the only witness for the first nine days. He was also a witness on two other days, and attended all the meetings of the Committee at which evidence was taken up to the day of his departure for England, 4th June.

At the time the Select Committee commenced its sittings the Press had a good deal of say about the unwillingness of the banks to finance the exporters of certain South African products, notably wool; and it would appear from their questions that a majority of the members of the Committee attached considerable importance to the necessity of finding some means whereby South African exporters would be relieved of their troubles. "There is one thing I am concerned with," said Mr. Macintosh, "and that is the unwillingness of the banks to finance the wool buyers." "Surely," he added, "you (the Treasury) and the banks should have been able to do something to save the situation." Sir Henry was able to assure the Committee that the gold certificate idea, which formed part of his scheme, would in all probability accomplish what they desired, as it would secure the banks against the withdrawal of their reserves and thereby enable them to resume the purchase of bills on other countries. This naturally created an impression on the majority of the Committee distinctly favour-

able to Sir Henry's proposals. Obviously, he was just the kind of adviser they had been looking for. They wanted a weather prophet who would at any rate promise to make rain, not a scientific meteorologist who would not even make promises. In the matter of currency investigations, Governments and Parliamentary Committees often act like kaffir tribes and some company promoters; they employ preferably experts who will support their own pet policies. The Government is still busy seeking salvation for the wool producers and the wool traders.

I have made extracts from the evidence of Sir Henry Strakosch (Appendix 8), from which you will gather that the views and doctrines of the practical man of to-day are precisely the same as those of the opponents of the Bullion Committee at the time of the Bank Restriction Act in England, 1797-1821, and of the inflationists during the Greenback era in the United States (1862-1879). The practical men who appeared as witnesses before the Bullion Committee also contended: "That the war could not be carried on without paper; that the balance of trade 'of course' drew off the gold; that it was impossible to resume (cash payments) while the exchanges were adverse; that Great Britain was in the debtor relation, and could not resume while she was so." "In short," adds Professor Sumner, "there is no possible fallacy now (1874) preached in the United States about paper money which was not then and there brought forward, with the single exception of the 'elasticity' notion." Sir Henry, it will be noticed, attaches great importance to the "elasticity" argument. He says, "If the notes are based on bills, then as the volume of trade expands, so will the note issue expand, and as the volume of trade contracts so the note issue contracts." (Q. 225, p. 106.)

I should add that Sir Henry also preached some sound doctrines. Like other celebrated inflationists, he worships at many shrines. He admits several of the first principles of currency, but he declines to apply these principles to our case. In fact, he stated: "One cannot apply any general rule or theories in regard to matters of currency. Each case stands by itself and has to be judged by all surrounding circumstances and conditions." (Q. 85, p. 41, Minutes of Evidence taken before the Select Committee on Embargo on Export of Specie.) The danger of being "faithless to the principles you have won," wrote Professor Bonamy Price over fifty years ago, "exhibits itself in a peculiarly insidious form in currency. I have rarely found men of any intelligence contest the first principles yielded by analysis. They are, on the contrary, almost universally accepted as truths so obvious as hardly to require statement. But the next moment those who were so impatient to assent come out with views in direct variance with the principles they so readily acknowledged; and then, when pressed with the contradiction, they pour out floods of arbitrary doctrine, which they do not pretend to have gained from analysis, and are almost sure to end with abusing their fellow-converser as a theorist." Those of you who have read the evidence will have noticed that Sir Henry, like almost all of the witnesses who appeared before the Bullion Committee in 1810, maintained at considerable length that exchanges are dependent on the balance of trade. A majority of the Select Committee accepted this view as sound, and in their Report they state: "Even if the exchange were brought to gold parity, its remaining at that point would depend upon the maintenance of an excess of visible and invisible exports over visible and invisible imports."

To enable you to realise how diametrically opposed Sir Henry's tenets and the conclusions of the majority of the Select Committee are to those of the orthodox English and American school of economists I append Professor Sumner's summary of the doctrines of the Bullion Committee (Appendix 9).

The impression was conveyed to the Select Committee, and later on to Parliament, that Sir Henry's views were approved of by Mr. J. M. Keynes, C.B., Joint Editor of the *Economic Journal;* Dr. G. Vissering, President of the Netherlands Bank, Amsterdam; Professor Gustav Cassel, of the University of Stockholm, Sweden; and other high authorities on currency. Speaking on the 5th July last, Mr. Burton, Minister of Finance, assured the members of the House of Assembly that "Mr. Strakosch was probably one of the first half-dozen recognised currency and exchange experts in the world." Later on (20th July, 1920), Mr. Burton said: "Mr. Strakosch has been recognised everywhere, by Mr. Vissering and other economists, as one of the most prominent exchange authorities in the world." Indeed, the majority of the members of the Select Committee were so impressed by Sir Henry's credentials as an exchange and currency expert that it never occurred to them that any of the other witnesses could

possibly have had his experience and knowledge of the subject. I was before the Committee for two mornings, but I was never asked as to my experience, although I believe on the currency problem I have had a considerably wider experience than Sir Henry. The representatives of three of the four political parties on the Committee appear to have accepted Sir Henry's doctrines practically without question. Apparently no attempt was made to verify his contention that there had been no excessive issue of paper money by the banks in South Africa. According to the Terms of Reference, the Committee had to enquire into the effect on the cost of living of the embargo on the export of specie. This was not seriously done. As far as I have been able to gather, no steps were taken to try and discover if there was any connection between the increase in the quantity of notes issued by the banks and the increase in prices in South Africa. The Union Census Department, under the direction of Mr. C. W. Cousins, collects and publishes detailed figures with index numbers dealing with the movement of prices and the cost of living in South Africa since 1910; but it does not appear that Mr. Cousins was ever asked to give evidence before the Select Committee or to supply it with information. The majority of the members contented themselves with theorising on the subject, apparently because they considered as conclusive Sir Henry Strakosch's statement that the increase that had taken place in prices and in the cost of living was due entirely to under-production and over-consumption brought about by the war. No doubt many of the members were also largely influenced by Mr. Asquith's statement in the House of Commons on the 15th March, 1920, that " there is no greater fallacy than to suppose that high prices are due to the multiplication of the currency."

General Smuts, speaking at Krugersdorp on the 10th of January this year, stated that the banking and currency policy of South Africa had been approved of by the greaest financiers in the world, and had been held up as a model for the countries of Europe to act up to. It is a little difficult to reconcile this statement with the actual situation as far as our currency and exchanges are concerned, and with the criticism to which our policy has been subjected by such an authority as Professor Cannan. Sir Henry Strakosch supplies the explanation in a letter which was published in the Press here on the 22nd of November last. Dr. Vissering and Professor Cassel, it seems, agree that it would have been unwise to remove suddenly the embargo on the export of gold, and they also approve of the arrangement for the centralisation of reserves—issues on which there was practically no difference of opinion. Indeed, long before the arrival of Sir Henry Strakosch there was, I believe, absolute unanimity here as to the advisability of centralising reserves so that they could be used to the best advantage in the event of a crisis, although some of us had proposed that this might be done in a less extravagant and more expeditious manner than by the establishment of a new bank. (Appendix 10.) See also an article by Mr. J. Postmus, the present General Manager of the Netherlands Bank of South Africa, entitled " Banks and Bankers in South Africa," published in the April, 1913, issue of the *Journal of the Institute of Bankers in South Africa.*) It is true that by adopting Sir Henry's plan we have followed the example of the United States, but it must be remembered that the United States needed the Federal Reserve Bank because their reserves were scattered amongst 32,600 separate banking institutions, whereas we have only four separate banking concerns in South Africa, which makes the creation of the South African Reserve Bank very much like the installation of a steam hammer in order to crack a nut. Then, again, as I have already indicated, many of us fully realised that the embargo on the export of gold could not be suddenly removed, but we wanted a date fixed, at any rate provisionally, for its removal, which was eventually done much against Sir Henry Strakosch's advice. It is on issues on which we differ from Sir Henry Strakosch that we should like to have had the views of currency and financial experts of the standing of Dr. Vissering and Professor Cassel. I know that Professor Cassel entirely disagrees with the balance of trade doctrine, which was the pivot on which Sir Henry's voluminous evidence hinged. In an article entitled " Further Observation on the World's Monetary Problem," published in the *Economic Journal* of March, 1920, Professor Cassel wrote: " I have directed during all the years of war a considerable part of my scientific work to efforts to destroy the popular fallacy that the movement of the exchanges could be explained by the balance of trade." Then, again, the Committee on Currency and Foreign Exchanges After the War, generally referred to as the Cunliffe Committee, and which included Professor

Pigou and some of the leading financiers in London, also disagree with Sir Henry's balance of trade doctrine. They held that "a sound system of currency would in itself secure equilibrium in the Foreign Exchanges," whereas Sir Henry contends that foreign exchanges "can only remain on a gold par if exports and imports (visible and invisible) are maintained in a state of complete balance." The fact is I could easily fill a volume with instances where Sir Henry's monetary theories differ from those of recognised currency authorities.

It appears from what transpired in the course of the investigations of the Select Committee and from the debates in the House of Assembly that General Smuts was influenced in favour of Sir Henry's currency theories by conversations and communications which he had had with a mutual friend, Mr. J. M. Keynes. I believe General Smuts used to be very friendly with and was in the habit of consulting the late Lord Courtney, and attached considerable importance to his advice. Lord Courtney was the pupil, friend and not unworthy successor of the great masters of monetary science, the school of thinkers who made the English currency system the envy and admiration of all nations and who made London the financial centre of the world. Lord Courtney was the author of the brilliant article on Banking in the Ninth Edition of the *Encyclopaedia Britannica*, and he was also one of the signatories of the Majority Report of the 1887-88 Royal Commission on Gold and Silver. Unfortunately, Lord Courtney died in May, 1918. I sometimes wonder what would have been the currency policy of South Africa had he lived another couple of years, and had he been consulted by General Smuts. Of one thing I am sure: he would have been as thorough as Professor Cannan in his condemnation of the more or less plausible fallacies contained in the Report of the Majority of the House of Assembly Select Committee. I cannot conceive Lord Courtney subscribing to the numerous doubtful economic doctrines which characterise that Report. I may add that General Smuts is not the first eminent statesman who has fallen a victim to the insidious doctrines of the practical man. As far as I know, Napoleon is the only outstanding instance in modern times of a distinguished leader of men who refused from the outset to have anything to do with paper money. Even the great Pitt succumbed, and a versifier of the time wrote—

"Of Augustus and Rome the poets still marvel,
That he found it of brick and left it of marble,
So of Pitt and of England they say without vapour
That he found it of gold and he left it of paper."

Before I close I wish to state that, notwithstanding its glaring defects, the Currency and Banking Act, 1920, is in several respects an improvement on what existed, and is, on the whole, better than Sir Henry's evidence and the Report of the Majority of the Select Committee would have led us to expect. Fortunately, Parliament did not allow itself to be entirely guided by what General Walker calls "the false popular philosophy" of the practical man. Although it does not consolidate the banking laws of the four Provinces, the new Act does provide for:—

A uniform minimum specie security for notes and deposits;

The centralisation of reserves;

The eventual termination of the competitive note-issuing privileges of the commercial banks;

The convertibility of the paper money into gold on and after the 30th of June, 1923, before which date the embargo on the export of gold will have been removed, unless Parliament decides to prolong the Moratorium Act after the 1st July, 1922.

Some of these objects might have been secured at an earlier date and in a less cumbersome and more straightforward manner; and the horizon would certainly have been brighter had the Government accepted whole-heartedly the provision for the termination of the inconvertibility of our paper money after the 30th of June, 1923. Unfortunately the Minister of Finance made it clear in the House of Assembly on the 26th July, 1920, that he did not approve of this provision, and that it was a concession which he made to meet the wishes of Parliament, reluctantly and "very much against his better judgment."

The future will depend in a large measure on the constitution of the Board of the Reserve Bank, and generally on the manner in which the Currency and Banking Act is administered. The past cannot be recalled; neither can we evade the penalties which sooner or later invariably follow the trans-

gression of economic laws. We can, however, so shape our course henceforth as to get back to sound money with as little delay as possible. The appointments that have been made to fill the posts of Governor and Deputy-Governor of the Reserve Bank are encouraging, and I believe that we can rest assured that, if not hampered by the Board, Mr. Clegg and Mr. Jorisson will do the best that can be done having regard to the terms of the Act which, as I have said, are not all satisfactory, and the currency and financial circumstances of South Africa at the present moment. Mr. Clegg has been trained in the best school in the world, and the traditions and high standing of the institution in the administration of which he took a leading part are a guarantee that he will endeavour to conduct the business of the Central Bank on sound and sagacious lines. Those of us who have closely followed the banking returns published quarterly in the *Government Gazette* in recent years, cannot but admire the conservative and safe course consistently followed by Mr. Jorissen as General Manager of the Netherlands Bank of South Africa, often at times when the inducement to overtrading was almost overwhelming. Having regard to their past, I am confident that I am not unduly sanguine in concluding that, provided their guns are not spiked by the Board, the Governor and the Deputy-Governor will not allow themselves to be led astray by the inflationist fallacies of the practical man, however plausible, and that they will administer the affairs of the bank with a firm conviction that no country is too poor to have sound money, and that the richest country cannot afford an unstable and disordered currency for any length of time.

Appendices.

7. Exchange Rates and the Balance of Trade.

8. The Monetary Doctrines of Sir Henry Strakosch.

9. The Doctrines of the Bullion Committee.

10. The Paper Currency of South Africa.

Appendix 7.

EXCHANGE RATES AND THE BALANCE OF TRADE.

The following letter was published in *The Star*, Johannesburg, on 18th July, 1920:—

Sir,

Mr. Burton is reported to have said in the House yesterday that I did not agree that the movement of exchange was subject to the law of supply and demand. As this may convey an erroneous impression, I should like to state that I believe in the law of supply and demand and in its universal application. I believe in the quantity theory, which is simply the application of the law of supply and demand to money. Where I differ from Mr. Strakosch and the official view is this: they hold that exchange rates depend chiefly on the balance of trade. On the other hand, I maintain that as a rule it is the general level of prices of exportable goods which controls both the trade relations and the rates of exchange of any two countries. If, for example, prices of exportable goods are 50 per cent. higher in England than in the U.S.A., people from the latter country will not buy in England unless the difference in the two price levels is reflected in the exchange rate. The general level of prices in any country depends in the main on the currency policy of that country. The extremely high price in marks which Germans have to pay when they buy pounds sterling in England and dollars in America is due practically entirely to the over-issue of paper money in Germany.

As a member of the Pretoria Committee, I did not approve of the Strakosch proposals, either as regards the gold certificates or the note-issuing powers of the central reserve bank. To avoid misunderstanding I wrote to the Minister of Finance on 23rd March making my position clear. I attach an extract of that letter. I consider that the necessity for the imposition and the maintenance of the embargo is conclusive proof of the excessive issue of notes by the banks, and that no scheme will arrest the upward movement of prices which does not make it to the interest of the banks to reduce substantially the quantity of paper money in circulation in South Africa.

(Sgd.) Samuel Evans.

Extract from a letter dated 23rd March, 1920, addressed by Mr. S. Evans to Mr. Orr, Minister of Finance:

Having pointed out that there were two, or rather, three, parties on the Committee which had met in Pretoria to examine the two Bills on Currency and Banking Reform, I proceeded:

"A majority of the Committee agreed with the Bills as finally drafted. My own view was that the banks were let off much too lightly as regards the note issue, and that, instead of the gold certificate arrangement, it would have been preferable to make the notes of the banks inconvertible for a

definite period, say, three months, provided the banks deposited with the Treasury gold bullion or gold coin representing the full face value of the notes in circulation. This arrangement would allow time for a thorough investigation by a Select Committee, and is identical with the third alternative proposed by Mr. Reyolds in a letter printed in the *Rand Daily Mail* of 4th February last. I may add that I am also opposed to the conditions suggested for the issue of notes by the proposed central reserve bank. It is a scheme which permits of the highest possible reasonably safe dilution of the currency with paper, and, apart from the total abandonment of the gold standard, it would be difficult to conceive a more disastrous plan as far as the gold mining industry is concerned. It will mean in time closing down three-quarters of the mines on the Rand.

"No report was written by the Majority of the Committee as it was understood that the whole question would be investigated by a Select Committee, and that we should in all probability be called upon to give evidence. However, to avoid any misunderstanding as to my views I have taken the liberty of sending you this letter."

Appendix 8.

THE MONETARY DOCTRINES OF SIR HENRY STRAKOSCH.

(Sir Henry Strakosch was one of the representatives of the Union of South Africa at the International Financial Conference which met at Brussels in September and October, 1920. He is President of the Financial Section of the Provisional Financial and Economic Consultative Committee formed by the Council of the League of Nations to advise on financial and economic problems. He was in South Africa from the beginning of January to the beginning of June, 1920, and was knighted on 1st January this year for his services in connection with the currency and banking problems of South Africa.)

The following are extracted from the Minutes of the Evidence given by Sir Henry Strakosch before the House of Assembly Select Committee on Embargo on Export of Specie. This Committee sat at Cape Town in April, May and June, 1920:—

1. "I want to emphasise that one cannot apply any general rule or theories in regard to matters of currency. Each case stands by itself, and has to be judged by all the surrounding circumstances and conditions." (Q. 85, p. 41.)

2. "The true gold standard cannot exist in a world in which the economic equilibrium is so completely upset as it is at present." (Q. 2690, p. 408.) "The gold basis has never been absolutely stable." (Q. 164, p. 74.)

3. Before the war "the gold standard was possible only because the countries of the world balanced their trade. The balancing of trade depends on production and consumption." (Q. 84, p. 38.) "In pre-war days exchanges moved within narrow limits because the trade of the world was balanced." (Q. 464, p. 151.) "The fact of the exchanges (prior to the war) only moving between certain points was due to the fact that the trade of the world was in a state of practically complete balance. To-day it is not." (Q. 84, p. 38.)

4. "The exchange can only remain on a gold par if exports and imports (visible and invisible) are maintained in a state of complete balance." (Q. 190, p. 84.)

5. "The exchanges will be kept at gold par, although there is no free export of gold, if otherwise, the trade is in balance." (Q. 85, p. 41.)

6. "It is because they (the belligerent countries excepting the United States) cannot balance their trade that their currencies have depreciated and therefore there is a gold premium." (Q. 468, p. 151.)

7. "So long as the imports of France, Russia and Germany did not exceed their exports, it did not matter that the currency was not convertible into gold, but it would have mattered if, in the long run, it had been the other way round." (Q. 40, p. 14.)

8. In the case of countries like Austria, it does not follow "that because a small balance of trade against a country exists the exchanges need move only to a small extent. Very often only a small adverse balance in a country creates a very much greater depreciation than may be justified by the small adverse balances." (Q. 41, p. 14.)

9. "Our exchange is governed by the foreign trade of South Africa, and also by the fact that the bulk of South African trade is with the Unied Kingdom." (Q. 411, p. 143.)

10. "You ask why the Union currency should depreciate concurrently with United Kingdom currency. It has depreciated no doubt because the trade of the Union wi'h the United Kingdom was constantly in balance." (Q. 71, p. 30.) "The premium

on our currency in relation to the United Kingdom currency . . . . is no doubt due to the fact that there is a balance of export from this country over imports of all kinds." (Q. 431, p. 147.)

11. "Mr. Creswell: As I understand the position, the American distrusts our currency to the extent that £100 of my currency is worth something like 23 per cent. less in his currency?—Mr. Strakosch: That is not necessarily distrust; that arises from the fact that on balance we have been importing more from America than we have been exporting to that country." (Q. 827, p. 193.) "If the whole of our trade were with America and if we had a balance of exports, visible and invisible, over imports, then our currency would be on a parity with American currency. That is, if we are not indebted to America and that America does not therefore withdraw capital from here." (Q. 830, p. 194.) "The crux of the matter is whether this country imports or exports more, whether the balance of its foreign trade is a balance of imports or of exports, visible and invisible." (Q. 829, p. 194.)

12. The currency of South Africa "has depreciated because economically it cannot stand on a gold par because our production for export is not sufficiently great to counterbalance the importation, not merely of goods but importations arising from invisible imports and these include, the withdrawal of capital." (Q. 206, p. 92.)

13. "You ask how it is that the banks here kept their exchange fixed for so many years until the last few months. That is simply because the foreign trade must have balanced, otherwise they could not have kept it at that figure." (Q. 32, p. 12.) "It was not only because our gold export was open. It was for general reasons. Our trade must have been in balance. The fact that the embargo is there made no difference in regard to the exchange with Great Britain." (Q. 33, p. 12.)

14. "The fundamental price movements of exchange are governed by supply and demand, which arise respectively from exports and imports." (Q. 216, p. 97.) "The supply and demand of exchange from the whole of our trade dictates the price at which our exchange stands. We do not export sufficient to bring our exchange to a gold par." (Q. 207, p. 93.)

15. "We have not departed from the basis that our currency is worth so many grains of gold. The only unfortunate thing is that there are people who are prepared to pay more than the gold in that sovereign is worth." (Q. 84, p. 37.) "What is happening to-day is that gold is sought after by people for other than currency purposes, and people are prepared to pay for gold what you may call a fancy price." (Q. 81, p. 34.)

16. The people of the East contrived to get gold from the United States, South Africa and elsewhere "by being large producers of raw materials; by an excess of exports—by being producers of raw materials which are greedily bought the world over." (Q. 819, p. 193.)

17. "I agree that the position is a very serious one indeed. The outlook for the future is bad, because experience has shown that once gold enters India it does not come out again." (Q. 95, p. 43.)

18. The price of gold will be brought down by "the saturation of the biggest buyer of gold, and to-day that biggest buyer is the East." (Q. 378, p. 139.) "The amount of gold in the world to equalise an excessive deficiency in the balance of trade is not sufficient to do that, and therefore the trade has to be equalised by production and by exchange of goods. When that exchange of goods does balance, then the need for gold will go down; that is so far as gold in gold standard countries is concerned, which are accustomed to settle their balances by shipment of gold. First of all you have to satisfy the East, where gold is used for hoarding; and for the rest the demand for gold will be smaller when they will be able to balance their trade by the exchange of goods and not by the shipment of gold." (Q. 379, p. 139, 140.)

19. "My own view is that the increase of prices is primarily due to under-production and over-consumption, and that these are due entirely to the conditions arising from the war." (Q. 82, p. 35.) "Higher wages are being paid on the railways because the cost of living has gone up, and the cost of living has gone up the world over because of under-production and over-consumption." (Q. 137, p. 65.) "Prices have gone up because of under-production and over-consumption." (Q. 140, p. 65.) "You cannot under-produce and over-consume without pledging your credit. These two facters together produce a rise in prices." (Q. 150, p. 72.)

20. "The fundamental rise and fall of prices is governed by the movement of world prices." (Q. 149, p. 69.) "The funda-

mental movement, theoretically, of prices in this country, whether we import or export these commodities, are those of world prices. In the case of export of commodities which we produce in excess of our own requirements and where we export the balance the prices which should be theoretically ruling here would be the world prices, less freight and insurance." (Q. 301, p. 128.) "What we must keep before us is that the rise in prices is world-wide." (Q. 151, p. 72.) "Our system of currency obviously cannot affect the world circumstances so far as the shaping of world prices goes." (Q. 150. p. 69.)

21. The lines on a chart prepared by Mr. Joseph Kitchin, giving the rise of food prices since the outbreak of the war up to October, 1919, "strikingly demonstrate that the gold par of exchange is not necessarily a panacea for the ill of rising prices. The United States of America, the greatest producer and exporter of foodstuffs, whose prices are only slightly vitiated by the influence of cost of freight, etc., has suffered a rise in prices almost double that of South Africa. It is abundant home production and the high price of freight, insurance, etc., which have kept a rise of prices in South Africa at so low a level as compared with other countries." (Q. 150, p. 70.)

(It will be noted in paragraph 11 above that at this time the South African currency was depreciated to the extent of 23 per cent., as compared with dollars.)

22. "The whole world, including ourselves, is living in a period of inflation brought about by the huge loans contracted by the various Governments, by which the immediate purchasing power of the people has been increased; that inflation is not confined to the borders of the State but it goes much beyond that, all the world over, and that increased purchasing power has had its effect upon commodity prices." (Q. 409 p. 143.)

23. "Mr. Saunders: Now the spending power to-day is simply due to the effect of note currency or low valuation of money?—Mr. Strakosch: No; let me put it this way. The increased spending power arises from the large amounts which have been brought into this country, and of the immediate purchasing power which accrued in this country, first of all, by this country raising loans, and, secondly, by the Imperial Government spending very big amounts of money in this country. I have figures here which give you a picture of the position. The Imperial war expenditure in South Africa has amounted to 22 millions sterling. The Union's war expenditure has amounted to about 30 millions sterling, altogether a total of 52 millions. Of this amount six millions sterling was expended outside the Union, so that the total amount expended in the Union is 46 millions sterling. The spending power, therefore, of South Africa has been increased by that amount. From this amount, however, you have to deduct whatever money has been raised by way of loans within the country and by taxation. There has been raised a matter of 10 millions sterling, I think, within the country, and £3,600,000 has been redeemed out of taxation, so that the spending power of South Africa has been increased by 32½ millions sterling, due to the war." (Q. 295, p. 127, 128.) "Mr. Saunders: Then you do not consider that the increased spending power has much bearing at all on this question in this country?—Mr. Strakosch: One cannot quite say that it has not. Do you not rather want to put it this way, that the increased note circulation in this country has that effect? If that is the question, then I say the increased note circulation has not had any material effect." (Q. 296, p. 128.) "Mr. Saunders: Then there is another point. Owing to the high wages in this country, there is an enormous amount of money spent to-day by persons who were not in a position to do so before. Is that merely due to the effect of the large amount of money brought into the country from outside sources due to the war, or is it due to any local conditions caused by the inflation of wages?—Mr. Strakosch: No; it is caused, first of all, by the immediate purchasing power having been increased by the Imperial Government spending money in the country, and then by the Union having raised loans outside the country. Of course, on top of that, it has been increased by the fact that South Africa has been selling its products at very high prices. That has produced the increased purchasing power of the people." (Q. 297, p. 128.)

24. "The embargo on gold does not vitally affect the position of the banks' exchange dealings; that depends on the supply and demand of exchange, and that arises from imports and exports in the widest sense." (Q. 273, p. 122.) "You consider that we would have been in exactly the same position as New York if the embargo had never been imposed, and if we had a continued

supply of minted gold coming in. I do not agree with you there. Every sovereign as you mint it and put it into circulation will disappear. If your supposition had been carried out you would have been minus that gold currency, and we would now have had an inconvertible paper currency." (Q. 81, p. 39.)

25. "My own view is that the note issue (in South Africa) has not been unduly increased." (Q. 70, p. 29.) "There is no doubt that there has been expansion in our currency, chiefly because the credit balances in the banks have increased. So far as the note issue is concerned, I do not think that there has been undue expansion." (Q. 81, p. 34.) "The note issue here, I do not think, taking everything into consideration, is excessive at all to-day (4/5/20), because the gold has for all practical purposes disappeared and notes have had to take its place." (Q. 410, p. 143.)

(The paper money circulation of South Africa increased from £2,150,000 on the 30th June, 1914, to £9,588,000 on the 30th April, 1920. Gold continued to circulate and the natives on the mines were paid entirely in gold up to the middle of December, 1920.)

26. The United States is in a position of considerable discomfort as the result of its return to a free gold market in June, 1919. (Q. 2690, p. 412.) Since that date it has been losing gold at an alarming rate (Q. 2690, p. 410); "gold which they needed badly as basis for their banking reserve." (Q. 104, p. 50.) "There is no doubt in my mind that the United States have severely suffered as the result of the appreciation of the dollar, and these ill effects will be accentuated when other countries begin to produce more extensively. First, their exports were hindered and their credit system has been, I will not say shaken, but they are finding themselves to-day in a distinctly uncomfortable position owing to the heavy withdrawals of gold." (Q. 156, p. 73.) "I am inclined to think, however, that if the authorities in America had foreseen what has actually happened, they would not have freed the export of gold, for the effect of that was shown in their present position. The whole credit structure has been weakened, so that to-day the Federal Reserve Banks are down with their reserves practically to the legal limit of 40 per cent." (Q. 159, p. 73); and the Government might be compelled to reimpose the embargo. (Q. 106, p. 51; also Q. 115, p. 52.)

27. "The disadvantage to the United States of maintaining a gold basis now is due to the present abnormal position of the world—it is due to the unbalancing of all trade all the world over." (Q. 158, p. 73.)

28. "It is quite correct to say that the appreciation of the American dollar and the depreciation of the sovereign have been the principal agents probably of preventing the United States from capturing the world's trade and enabling Great Britain to compete with her." (Q. 60, p. 25.)

29. "For South Africa in the world conditions, as they exist to-day, to venture upon a course which would compel it to share alone with the United States of America the burden of supplying the insatiable demand for gold the world over is clearly an experiment of a most hazardous kind." (Q. 99, p. 17.) "If you allow the free export of gold every holder of notes or credit balances will run to the banks and demand gold and the banks would rapidly lose every farthing of their reserve." (Q. 201, p. 89.) "We do allow raw gold to leave the country, but it is a commercial product, just the same as wool, but if you run to the bank and you want to change your credit balance or your notes into sovereigns, and you export these sovereigns, you are draining their reserves and you can see what the upshot of it all will be." (Q. 202, p. 89.)

30. "There is no purely automatic way of preventing inflation or of carrying through deflation." (Q. 2690, p. 411.) "Production and economy alone can right the position of the currencies, exchanges and international trade generally." (Q. 2690, p. 410.) "Without increased production and economy the expedient of raising our exchange here to gold par is not going to solve the difficulty, but will simply tend to produce a financial crisis. The deflation of currency by raising our exchange cannot affect the economic position unless there is increased production all round." (Q. 152, p. 72.)

31. "It is impossible for any human being to say when the trade of the world will be in a state of balance, and that is why I say that no man can foretell at what time we shall be in a position to revert to the gold standard." (Q. 2696, p. 413.) "The question of re-establishing the gold standard in any country cannot be judged exclusively by local circumstances . . . .; it depends in a very high degree upon the re-establishment of an economic equilibrium in the rest of

the world. Who will be bold enough to prophecy when that is likely to eventuate? But even in regard to local circumstances any forecast as to when the country will be in a position to face the hazards involved in the re-establishment of the true gold standard must be a crude guess." (Q. 2690, pp. 410 and 411.)

32. "World conditions to-day are such that we out here cannot revert to the true gold standard without causing a very great economic upheaval in the country." (Q. 155, p. 73.) The removal of the gold embargo to-day "would impede production, and it would foster importation, reduce our exports, and would lead to the withdrawal of capital from this country"; (Q. 489, p. 155); "it would impose a huge hardship on South Africa." (Q. 158, p. 73.) "If we have a rapid return to the gold parity it will bring disaster; (Q. 837, p. 194); "it will result in a severe crisis"; (Q. 215, p. 97); it will "lead to a complete breakdown of credit and of all our activities"; (Q. 492, p. 156); "our industries and trade will be enormously restricted"; (Q. 206, p. 92); and "thousands of people would be thrown out of employment." (Q. 138, p. 65.) "I contend that although the immediate result of raising the exchange to gold par would be beneficial to the consumer, the ultimate result would be non-beneficial, considering the effect of the change on the community at large—the mines, industries, agriculture and so on. The period of the change would be pretty rapid. Every violent change in economic conditions produces a crisis, and you know what a crisis means. It means great hardship, probably ruin, to everybody —capitalist or working man." (Q. 139, p. 65.) "If you allowed the free export of gold, I have no doubt that every sovereign would disappear." (Q. 84, p. 38.) "The country would be completely denuded of currency, and I have no doubt that steps would have to be taken to provide the country with a currency; in that case the only currency I can see to tide over this chaotic condition would be an inconvertible paper currency. The gold would have left the country and some currency would have to be provided." (Q. 490, p. 156.) "If there were free export of gold, the country would be drained of its gold in a very short time, and the exchange would then become disorganised and credit would eventually break down. If the whole of the currency leaves the country, the Government will have to step in and provide currency, and the only thing I can see is that the currency would be an inconvertible one backed by the security of the State only, quite apart from the disaster which is bound to happen if the banks are drained entirely of their reserves." (Q. 84, p. 40.)

33. It would, therefore, be a mistake to remove the embargo on the export of gold or to attempt to fix any date for its removal. "It is not possible at this juncture to fix upon any definite time when the embargo can safely be removed. Any attempt in that direction can only be a wild guess." (Q. 2690, p. 411.) "Automatically, with our export trade improving, our currency will improve, until the time will come that our currency will be on a par with gold." (Q. 471, p. 152.) "You will have to keep on an inconvertible basis until such time as our currency has appreciated to the gold par. It may momentarily go up to par and fall again." (Q. 472, p. 152.) "The question is when is our foreign trade so well balanced and so secure that the exchange will not go adversely to this country, and only in that case can gold circulate freely without danger of being exported. (Q. 473, p. 152.)

34. "I say that the United States might be compelled to prohibit gold going out, and it is exactly what I suggested in this pamphlet that we should do here. We should make it impossible in the extraordinary world conditions as they exist to-day, for anyone to demand gold for the purpose of export." (Q. 106, p. 51.) "Legislation should be introduced authorising the Government to create what may be termed Treasury Gold Certificates." (Q. 216, p. 98.) These certificates should be fully backed by gold coin or bullion locked up in the Treasury. They should be legal tender and "should be made convertible into gold, but the Government should be relieved of that obligation so long as gold commands a price in the world's market which exceeds the standard price." (Q. 219, p. 99.) "The only sort of prohibitive measure which can stop this leakage of gold in America or South Africa is something of that sort to make State notes which are inconvertible; that is my scheme." (Q. 108, p. 51.) "What will happen if the proposed gold certificates were introduced is that the banks who hold practically all the gold in the country would take that gold immediately to the Treasury and get gold certificates because in that form reserves will not be withdrawn from them. Their reserves will not be tramped upon.

Then those gold certificates will take the place of the gold as backing of the existing bank notes and later on the gold certificates will probably go into the Central Bank which will issue its own notes in place of the existing bank notes." (Q. 200, p. 89.) "The adoption of my scheme would mean the disappearance of gold from circulation." Q. 127, p. 60.) "As to the advantage of issuing gold certificates the position to-day is this, that, owing to world conditions, gold commands a price in the world's market, especially in the East, which is so high that it is an inducement to people in this country to collect gold coins and export them, and that is happening every day. The Chairman tells us that the loss of gold in this way last month amounted to £470,000. The advantage of my scheme is that in the form of notes our currency cannot be withdrawn from circulation, but in the form of sovereigns our currency can be withdrawn from circulation, sent abroad and sold there. The withdrawal of this gold coinage weakens the reserves of the banks, and as they can only do credit business based on their currency reserve they have, as their gold reserves diminish, curtailed credit. The gold certificates which I suggest would be of no use to an Indian in India, so there would be no inducement to export them. I propose that these gold certificates should be converted into gold when the gold premium has disappeared; that is, when the inducement for sending sovereigns abroad has also disappeared." (Q. 210, p. 94.)

35. "Now you ask me what is the cure for the present condition of affairs under which people who deal in wool are being prevented from selling their wool in London as a result of the actions of the banks. My reply to that is that the cure is to secure the banks' reserves, and so long as the banks can be made to pay out sovereigns, so long are their reserves not secure. Therefore, to my mind, the only cure is to create the suggested gold certificates." (Q. 193, p. 87.) "On the particular question which you asked, whether the banks will be more prepared to take your wool drafts, I say that if by the adoption of the gold certificates proposal the reserves of the banks are made safe, they will again do business." (Q. 279, p. 124.)

36. "The establishment of a Central Bank economises the gold needed for currency purposes." (Q. 538, p. 161.)

37. In future paper money should be issued on the basis of 40 per cent. of gold or Treasury gold certificates and 60 per cent. of "genuine commercial Bills of Exchange of not more than ninety days' currency and bearing three signatures." (Q. 224, p. 103.) Under that arrangement a backing of eight millions in gold or gold certificates, together with £12,000,000 of bills, would create £20,000,000 currency. (Q. 280, p. 125.) Such a currency would be elastic and would expand and contract automatically according to the needs of the trade of the country. (Q. 257, p. 116, and Q. 225, p. 106.)

38. He would not be in favour of fixing a limit to the quantity of notes issued "because the quantity of notes required depends entirely on the size of trade, and the quantity of notes should be a constantly varying figure according to the size of trade, I think, I explained the other day. If a country were to exchange goods at the rate of one million sterling per day and the velocity of money were seven days, then that country would need to carry on its trade seven millions, but if that trade were for one reason or another to double, either because the price of the goods was doubled or because the volume of trade was doubled, then that country would need, not seven millions but fourteen millions. Therefore I do not think that it would be wise to limit any issue of notes, but rather allow the amount of notes to be determined by the trade of the country, and that is best achieved by basing these notes to a large extent upon the bills of exchange, genuine bills of exchange, which represents goods." (Q. 389, p. 141; see also Q. 239, p. 109; Q. 216, p. 98; Q. 225, p. 106.) "Trade expansion and high prices may lead to a state of things where the amount of currency is not sufficiently great." (Q. 218, p. 99.) "This was America's experience in 1914 when there was a crisis due to the insufficiency of currency." (Q. 219, p. 99.)

39. The embargo should be retained "concurrently with the issue of inconvertible notes." (Q. 443, p. 148.) There can be no inflation in the case of notes issued against 40 per cent. of gold and 60 per cent. of commercial bills. (Q. 2690, p. 412.)

40. The English system of a fixed limit to the fiduciary note issue "is possible only because in England the Joint Stock Banking system is so wonderfully developed. The country does not use bank notes or coin as the medium of exchange, but uses cheques. Therefore the need in England for bank notes

and coin is much smaller than in other countries, and they can therefore afford to make their bank note issues fully backed by gold." (Q. 257, p. 117.)

(The references are to the questions and pages of the Report of the Select Committee on Embargo on Export of Specie printed at Cape Town by the Government Printers, Cape Times, Limited, in June, 1920.)

Appendix 9.

DOCTRINES OF THE BULLION COMMITTEE OF 1810.

Professor Sumner in his "History of American Currency," sums up the doctrines enunciated in the Report of the Bullion Committee of 1810 thus:—

1. The value of an inconvertible currency depends on its *amount* relatively to the needs of the country for circulating medium only to a very subordinate degree on the security on which it is based or the credit of the issuer).

2. If gold is at a premium in paper, the paper is redundant and depreciated. The premium measures the depreciation.

3. The limit of possible fluctuations in the exchanges is the expense of transmitting bullion from the one country to the other. If it costs 2 per cent. to transmit bullion, the fluctuations of the exchange due to the ratio of imports and exports never can exceed 2 per cent. above or below par. Par of exchange is the par of the metals, weight for weight, in the two coinages.

4. If there is a drain of the precious metals, it is due, aside from exportations to purchase food or pay armies, etc., to the presence of an inferior currency of some sort in the country it leaves.

5. If the inferior currency be removed, the exchanges will be turned, the outflow will stop, and, if any vacuum is created, gold will flow in to supply it.

Gold will not flow in while the inferior currency fills the channels of circulation.

6. In the presence of a panic the duty of the Bank is to discount freely for all solvent parties.

The still more fundamental laws involved are these:

1. The amount of gold in the world will suffice to perform the exchanges of the world. If there be more or less, it will only affect the average level of prices the world over.

2. Every nation will have that portion of the stock of gold in the world which is proportioned to its trade. Each nation will have just as much as it needs.

3. A better and a worse currency cannot circulate together. The worse will drive out the better.

The Committee also incidentally condemn the usury law and the law forbidding the exportation of the precious metals.

"The Report of this Committee," says Professor Sumner, "is perhaps the most important document in financial literature. Its doctrines have been tested both ways, by disbelief and by belief, by experiment of their opposites and by experiment of themselves. They are no longer disputable. They are not matter of opinion or theory, but of demonstration. They are ratified and established as the basis of finance. They may be denied, as the roundness of the earth was denied even five years ago, and as Newton's theory of the solar system was denied until within twenty-five years, but they have passed the stage where the scientific financier is bound to discuss them."

Professor Sumner points out that the witnesses who gave evidence before the Bullion Committee were bankers, merchants and bullion brokers, and that it appeared from their statements "that there was a widespread belief that it was not the paper which had depreciated, but the gold which had advanced—a notion which has been advanced in other periods of paper money."

The Bullion Committee put the depreciation of the bank notes at the time at 15½ per cent.

Professor Sumner adds:—

"The witnesses, almost without exception (and the exceptions were not clear and precise in their opinions), maintained that the adverse exchange was due to an adverse balance of trade or of payments. The question involved was, therefore, this: Is an adverse balance of trade the explanation of an outflow of gold?—or: Is a favourable balance of trade the force to which we must look to bring an influx of gold? There is no question in finance which now demands our study so imperatively as this one. The false notions of the balance of trade infest almost every discussion of our present circumstances which one reads or hears. It is assumed that the movement of the precious metals from country to country is caused by the balance of trade one way or the other, and, as the movement of the metals

is a phenomenon of the first importance in any question of resumption, the reasoning which starts with this doctrine is all fallacious. The balance of trade was exploded by Quesnay and his followers a century ago, and was gibbeted in the Bullion Report, but it stalks the money market and the national treasury to-day, an uneasy ghost, which it seems impossible to lay.

"It is a vexatious task, and one which always makes a scientific man feel ridiculous, to set vigorously to work to demolish an old error which no well-informed man any longer holds."

Appendix 10.

THE PAPER CURRENCY OF SOUTH AFRICA.

(Memorandum prepared at the request of the Minister of Finance and communicated to the Treasury on 18th March, 1919.)

(1) There are in the Union five banks issuing notes under conditions which put a premium on inflation. The more notes the banks can put in circulation the more profit they can make for their shareholders. The public are not sufficiently protected, and there is no pooling of reserves so that in case of a crisis there is bound to be a scramble for reserves amongst the banks.

Mr. Warburg, of the U.S.A. Federal Reserve Board, writes:—

"A system which scatters and decentralises reserves making them unavailable and insufficient in case of need is fundamentally wrong and defective."

(2) In Europe the privilege of issuing notes is restricted to official banks which centralise reserves and "which are hemmed in by such regulations as keep them out of speculative business or general commercial transactions." In India, the Government issues notes with safeguards against over-issue. Canada combines a Government with a banking paper currency.

(3) The U.S.A. reformed its banking and currency legislation in 1913 as the result of a most thorough investigation by the National Monetary Commission. Up to 1913 the U.S.A. had a system of note issue by banks against securities similar to that of the Cape Colony, but with more effective safeguards against inflation. I believe that the Cape Colony Act of 1891 was modelled on the old U.S.A. system. That system was found most defective, and was partly responsible for the crises of 1893, 1903 and 1907.

Professor Seligman, writing in 1914, stated that—

"The real pith of modern banking is the question of reserve, and the essential weakness of the American system (before the passing of the Federal Reserve Act) was the extreme decentralisation of resources resulting in time of stress or trouble in every individual bank attempting to secure its own solvency in disregard either of the welfare of the other banks or of the needs of the business community. Without some method of combining the scattered resources of the individual banks, it was clear that no essential pregress could be made."

The national banks system, with its bond-secured paper currency, was created by the U.S.A. Government in order to provide funds to finance the Civil War. The Government bonds carried 2 per cent. interest, and after paying the tax the banks earned only 1 per cent. The U.S.A. Government "imposed a 10 per cent. tax on State bank note circulation in order to force it out of existence, and at the same time to force the State banks into the national system."

(4) Judging by the evidence of leading authorities before the U.S.A. National Monetary Commission, I should say that banking and currency reform in South Africa should aim at—

- Uniform banking and currency legislation for the whole Union;
- the provision of adequate securities for the public, both as regards notes and deposits;
- the centralisation of the reserves in a national bank or in some other way so that they can be used to the best advantage in a crisis;
- the entire elimination of private profits on notes, and adequate and efficient safeguards against over-issue.

(5) Theoretically the best solution would be for all currency notes to be issued by the Government. The probabilities are, however, that such a proposal would meet with strong opposition. In an address before the Academy of Political Science, New York, in October, 1913, Senator Aldrich, Chairman of the U.S.A. National Monetary Commission, stated—

"It can hardly be necessary for me to recount in this presence the disastrous results which have inevitably followed the issue of paper money by Governments or States. . . . Leading economists, financiers

and statesmen of every shade of political belief have joined in the condemnation of the use of the obligations or notes of Governments as a circulating medium. . . . In the thorough re-examination of banking and monetary questions which has recently taken place in Germany, Switzerland and elsewhere, no representative of any party and no individual appeared to favour the substitution of Government notes for bank notes." (Volume IV., No. 1, Proceedings of the Academy of Political Science, New York.)

(6) It may not be practical politics to attempt to pass through Parliament in the present Session a Consolidated Banking Act to remedy all the defects of the present system. The problem is an extremely complicated one, and no doubt Parliament will insist on considerable investigation and discussion which will inevitably mean great loss of time. It is important, however, that we should put our house in order to some slight extent at any rate without delay, as a world financial crisis may be upon us at any moment. That being the case, it may be preferable to introduce temporary legislation immediately to remedy the most glaring shortcomings of the present system so that South Africa is put in a position as soon as possible to face any financial crisis that may occur in Europe in the near future.

(7) It seems to me that the line of least resistance would be in the following direction:—

To take the Cape Act as a basis, extend its operation to the whole Union, and amend it on some such lines as the following:—

All banks issuing notes to deposit with the Union Treasury (or the Public Debt Commissioners) Government securities for the full value of the notes issued;

The notes to be supplied by the Treasury on the same terms as under the Cape Act;

The banks to maintain a reserve in gold equal to—

	Standard Reserve %	Minimum Reserve %
of the notes in circulation	40	15
of the demand liabilities	20	10
of the time liabilities	10	5

Any deficiency in the standard reserve required to be subjected to a graduated tax which would amount to 10 per cent. when the minimum was reached;

All notes in circulation not covered by gold or issued in excess of the paid-up capital of the banks to be subject to a tax of 3 per cent. (that is, a bank with a reserve of only 15 per cent. of the notes issued by it would have to pay a graduated tax varying from 2½ per cent. to 10 per cent. on 25 per cent. of its notes, *plus* 3 per cent. on 85 per cent. of its notes. The 3 per cent. tax on the difference between the actual reserve and the notes in circulation still leaves South African banks in a better position than that of the old national banks in America, as the U.S.A. bonds, which the national banks had to deposit, carried only 2 per cent. interest).

The minimum reserve should be held by the Government (or the Public Debt Commissioners), and be under the control of a reserve board composed of, say, three representatives of the Government and three representatives of the banks, with the Minister of Finance as Chairman. The reserve would have to be kept in gold coin. The Board should have full powers as to the use to be made of the reserve in time of crisis.

After the establishment of the Mint the banks should be allowed to treat gold at the Mint or in transit as a part of their standard reserves.

(Such an arrangemnt will operate to keep exchanges low and will also facilitate the exportation of surplus gold.)

All the notes issued must be convertible against gold on demand at the head offices of the banks in the Union, and at the Pretoria, Cape Town, Bloemfontein and Pietermaritzburg offices, if the banks have offices in these towns.

18-3-19. (Signed) SAMUEL EVANS.

THE KATA-THERMOMETER AND ITS PRACTICAL USE IN MINING.

By H. J. IRELAND, M.B.E., A.M.I.C.E.

(*Printed in Journal, November, 1920.*)

DISCUSSION.

Mr. C. J. Gray (*Member of Council*): We are indebted to Mr. Ireland for his interesting and valuable paper. Some of

us knew that Dr. Hill had shown the importance of air movement as well as temperature, humidity and purity, but it cannot be said that Rand mining practice has been guided by that knowledge. Mr. Ireland's clear exposition may do much to spread knowledge of the facts, and to induce their application.

The Kata-thermometer should greatly assist in the study of those questions of mine ventilation, and their bearing on health and efficiency, in which fortunately interest is now arising. Its intelligent use may thus help in overcoming miners' phthisis, but I wish to speak a word of warning against action based on Kata readings alone. According to present knowledge, silicosis, the uncomplicated form of miners' phthisis, is produced by microscopically fine air-borne silica dust. In close places, with little or no air current, the dust produced by mining operations accumulates, so that the amount of dust per cubic centimetre becomes larger than in a better ventilated place where even more dust is produced. At present there is the safeguard that such a place becomes noticeably unpleasant to persons working or travelling there, and an obvious inducement to supply fresh air is provided, that being the only way of improving conditions which would occur to most mining men. If, however, it becomes generally realised that local stirring of the air in the place will produce satisfactory Kata readings, and therefore satisfactory cooling effect and comfortable conditions, there will be some risk that the necessity for a fresh air current to remove the invisible dust will be overlooked. Either high CO_2 results, or high temperatures are better indirect indications of danger from dust than unsatisfactory Kata readings.

Use of the Kata-thermometer will produce a wish to reduce the humidity of mine air. Possibly it is desirable to do so, as humidity may perhaps encourage the development of miners' phthisis, but the danger of dust is more certain, and I consider the effect of condensation of moisture as air currents fall in pressure and temperature, very important in clearing dust out of the air and keeping mine surfaces moist so as to prevent dust from rising. Reduction in humidity of the air current should therefore be made only after careful consideration.

What I have said is not intended to discourage the use of the Kata-thermometer, but is merely a plea for intelligent and temperate application of its results.

NOTES ON THE INFLUENCE OF SOLUBLE SILICA AND CALCIUM SALTS ON PRECIPITATION

By J. HAYWARD JOHNSON.

(*Printed in Journal, October, 1920.*)

DISCUSSION (*Contributed*).

Mr. H. R. Adam (*Member of Council*): In Mr. Johnson's paper it is stated that the soluble silica is ". . . . deposited on the zinc in the 'gel' form by chemical or galvanic disturbance." I made a few experiments on this aspect of the subject, which may be of interest, although a much more extensive investigation is desirable.

The fact that the silica is not precipitated in the sand and slime vats indicates that its deposition in the zinc boxes is not due to a surface effect or adsorption. To confirm this, however, a cyanide solution (0·05% KCN), containing a little silica (0·17% SiO_2) added in the form of water glass, was kept in contact with such surfaces as powdered quartz, powdered pyrite, granulated lead, zinc shavings, and finally lead-coated zinc. Only with the latter did any precipitation occur; in this case, after twelve hours' contact, the dissolved silica was reduced to 0·02%.

This result supported the statement in the paper already referred to, and further confirmation was obtained by electrolytic tests on similar solutions, using sheet zinc anodes and lead foil cathodes. With an E.M.F. of 1·8 volts precipitation of the silica is fairly rapid, and the gelatinous precipitate consists chiefly of silica and zinc hydroxide. If a porous clay diaphragm separates the anode from the cathode the silica is only precipitated effectively in the anode compartment whilst the alkalinity decreases. In the cathode compartment a small proportion of the silica precipitates and the alkalinity increases.

Figures from one such test were as follows:—

	%
Dissolved Silica in original solution	0·194
Dissolved Silica (anode) after $1\frac{1}{2}$ hours	0·074
Dissolved Silica (cathode) after $1\frac{1}{2}$ hours	0·144
Dissolved Silica (anode) after 4 hours	0·014
Alkalinity as NaOH (anode) after $1\frac{1}{2}$ hours	0·08

Alkalinity as NaOH (cathode) after $1\frac{1}{2}$ hours	0·12
Alkalinity as NaOH (anode) after 4 hours	Nil
Alkalinity as NaOH (cathode) after 4 hours	0·14

In this test a rather high E.M.F. was used (viz., 3·6 volts) and a voluminous precipitate resulted, consisting chiefly of zinc hydroxide, in addition to the silica. The initial current was about 0·2 amps, but rapidly fell off as the anode became covered with the precipitate. The silica does not adhere firmly to the anode; in fact, turbidity soon appears throughout the cathode liquid till finally the gelatinous precipitate settles out; a good deal of the latter adheres to the clay diaphragm.

From these results there seemed three possibilities. First, that it was simply a case of direct electrolysis of the sodium silicate, in which case the ions $2Na^{\cdot\cdot}SiO_3''$ would exist in the solution. With one or two exceptions,(1) most authorities agree that the soluble alkali silicates do not exist in solution as simple salts, but that the solution consists of the alkali and colloidal particles of silica. If the silica existed as the ion SiO_3'' one would not expect migration to be stopped by a porous clay diaphragm; on the other hand colloidal particles, even of ultra-microscopic size, would be stopped. This would account for the less effective precipitation in the cathode compartment.

The second possibility is that the phenomenon known as "cataphoresis" or migration of colloidal particles under the influence of an electric current, takes place. According to Zsigmondy(2) particles of stannic oxide, silica and other oxides in the colloidal state are charged negatively and would consequently migrate to the anode in an electrolytic cell. It would be rash on the insufficient evidence available, to say that this, in the case under consideration does not take place. That it is the main cause of the precipitation hardly seems likely, however, in view of the fact that on the electrolysis of solutions containing small quantities of dissolved silica, using insoluble platinum anodes no macroscopically visible precipitation occurs. In one test a cyanide solution (0·05 % KCN), containing 0·017 % dissolved silica was electrolysed for forty-eight hours at an E.M.F. of 3·6 volts without a sign of turbidity.

(1) Zsigmondy *Chemistry of Colloids*, pp. 73 and 135.
(2) Ibid, p. 75.

The third possibility seems the most probable, viz., that the immediate cause of the precipitation is the soluble zinc compound formed at the anode. According to Bancroft(3) sodium zincate is to be regarded as a colloidal solution of zinc hydroxide, which is very unstable, and rapidly deposits zinc hydroxide as a gelatinous precipitate. If this is correct it might be expected that the zinc hydroxide in precipitating would bring down with it the silica, in which case we should have an example of the mutual precipitation of colloids.

The following experiment was, to a certain extent, confirmatory of this idea, although further evidence is required:—500 cc. of a cyanide solution (0·05 % KCN) and alkalinity 0·03 % as NaOH, with no dissolved silica was allowed to percolate through a column of lead-coated zinc shavings 70(cm.)^3 in volume, at the approximate rate of 1cc. per minute. The receiving vessel contained 50cc. of a weak "waterglass" solution (0·17 % SiO_2). The issuing liquid was clear, but became turbid in the receiving vessel. After standing twenty-four hours, the silica still remaining in solution was estimated, and it was found that 30 % of the total had been precipitated.

On examining some samples of working cyanide solutions kindly sent me by Mr. Johnson and Mr. Maxwell, I was surprised to find how small was the quantity of dissolved silica, particularly as the samples came from mines where precipitation troubles were fairly common. The following were the results of partial analysis in parts per 100,000:—

No. I. (head of box)—	
Dissolved Solids	100·4
Loss on ignition	12·0
Silica and insoluble	7·0
No. II. (foot of box)—	
Dissolved Solids	102·2
Loss on ignition	12·0
Silica and insoluble	6·4
No. III. (head of box)—	
Dissolved Solids	118·8
Loss on ignition	14·8
Silica and insoluble	4·4
No. IV. (foot of box)—	
Dissolved Solids	115·8
Loss on ignition	13·0
Silica and insoluble	4·6

Judging from these figures, the rate of

(3) Bancroft, *Second Report on Colloid Chemistry*. Brit. Assoc. Advancement of Science, p. 3.

flow through the zinc boxes is too great for the precipitation of such small amounts of silica, and to check this percolation, tests similar to that described above, except that the head solution contained silica, were carried out. The rate of flow was about 1 cc. per minute. In the case of working cyanide solution No. I. it was found that 9% of the dissolved silica was precipitated, and in the case of a solution containing "water glass" (17·6 parts silica per 100,000), 43% was precipitated. The addition of the water glass means higher alkalinity, and with high alkalinity a greater amount of zinc is dissolved, which might account for the much higher proportion of silica precipitated in the latter test.

There is another aspect of the subject which should be touched on. What would be the effect of the silica deposition on the gold precipitation. Consideration of this could not be confined to silica alone, however, but to the formation of "white precipitate" generally. The explanation of the effect of such incrustations generally given is simply that the active surface of the zinc is reduced, but I doubt if this is sufficient. According to the generally accepted theory, when gold is precipitated from double cyanide solutions, the ion $AuCy''_2$ migrates first to the anode, but is eventually decomposed by the sodium (or hydrogen) at the cathode. Any considerable deposition of gelatinous precipitate would conceivably hinder the free movement of the $AuCy_2$ ion, and some of the gold might be adsorbed on the gelatinous precipitate. This would not explain a high gold value for the effluent solution, but it must be noted that the coagulation of the silica and zinc hydroxide does not take place rapidly, and the first result is the formation of a slightly opalescent solution, which might yet have a considerable effect on the precipitation in carrying off gold. These are suggestions indicating that there may be other causes of poor precipitation than the mere reduction of precipitating surface. I notice that there is a considerable quantity of gold and silica present in the deposit discussed by Mr. Johnson, and in many of the silica residues obtained in my experiments I observed a pink colouration, probably due to gold, but I have no figures on this matter.

I do not know whether any suggestions of practical value can be made from the points raised. In Graham's classical paper on colloidal silica[1] it is stated that very small additions of sodium hydroxide are sufficient to bring the gelatinised silica to the "sol" state. This might help in the matter of the clogging of the filter leaves. In this connection I notice two somewhat contradictory statements in the paper. In one paragraph quoting from a report it is stated that, "The mixture is very readily soluble in dilute acids." This does not agree with the existence of the silica "gel" in the residue from acid treatment, which is the cause of the clogging of the filter-press mentioned later.

With regard to the possible purification of the solutions in the storage sumps, assuming that the preventative measures recommended by Mr. White are not always possible, the addition of sufficient sodium carbonate would probably be too costly. In one test on No. II. working solution, one part by weight of sodium carbonate per 5,000 of solution precipitated approximately one-sixth of the total dissolved solids and one-fifteenth of the silica.

The President: Before we close, I should like to draw your attention to the fact that our reading room is open all day, so that any of you who are passing by and who care to come in at any time, may do so.

The meeting then terminated.

[1] Extracts from Graham's original papers on colloidal silica are contained in Zsigmondy's *Colloids and the Ultra Microscope*.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

PRODUCTION OF POWER FROM BLAST-FURNACE GAS.—"It is estimated that 1,000,000 h.p. is being constantly wasted in Great Britain in the form of potential energy from blast-furnace gas. The use of blast furnace gas for boiler-firing is uneconomical, as even with modern plant and clean gas only 30% efficiency is attained. In present practice 40% of the gas is used on the stoves, 15% on the blowers, and none on the boilers, so that 45% is available for other purposes, equivalent to 2000 k.w.-hours per furnace per hour. The furnace blowers require 800 h.p., taking 0·2 ton of coal and 15% of the gas, the total B.Th.U.s required being 20,824,000. The economy on 50 furnaces amounts to 400,000 tons of coal per annum, which is almost equal to the coal required to produce the total units sold in 1911-12 by the 303 electricity works in the United Kingdom. The Halberg-Beth plant for gas-cleaning is recommended, the potash being recovered and the moisture being removed from the gas, making it better for gas-engine use. The residual dust is given as 0·002 gm. per cub. m.—S. H. FOWLES, Inst. Elect. Eng., 11.3.20.—*Engineering*, 1920, *109*, 443-445.—*Jour. Soc. Chem. Ind.*, 31st May, 1920, p. 371A. (J. A. W.)

MISCELLANEOUS.

Iron Industries in South Africa.—A review of the production of the iron and steel industry is contained in the annual report of the Secretary for Mines and Industries. The Union Steel Corporation's Works at Vereeniging had a successful year, the production being 10,318 tons of open hearth steel from scrap or pig, the value of the output being £200,753. The newly installed $3\frac{1}{2}$-ton Heroult electric furnace had ten months' work, and produced 13,945 tons of steel of the total value of £30,485. Most of this output goes to the mines in the form of shoes, dies, rails, and tube-mill bars. The Corporation are now arranging to forge the shoes and dies after casting by means of a 600-ton hydraulic press. The Transvaal Blast Furnace Company produced 676 tons of pig-iron of the value of £2,855. The output of pig-iron by the Pretoria Iron Works was 1,286 tons of the value of £9,645. It is intended to increase the capital and to work on a much larger scale, and to produce not only pig-iron, but also steel in the form of angles, bars, tees, beams, rails, sleepers, etc. At the Dunswart Iron and Steel Works little alteration has taken place. During the latter part of last year an 8-inch roller mill was installed, and the average monthly output increased to about 550 tons of bar, rod and angle iron. The total output was 5,596 tons, of the value of £139,660. The total output of shoes and dies by the Witwatersrand Co-operative Smelting Works was 1,043 tons, of the value of £22,400. The Newcastle Iron and Steel, Ltd., are erecting plant at Newcastle (Natal) to produce pig-iron from ore, open hearth steel, and iron and steel castings up to 20 tons weight. This company expects to start smelting in October, 1920. The production of iron and steel is now attracting great attention, and the country is on the eve, apparently, of large expansion in this new branch of industry. The total value of iron and steel goods produced in South Africa in 1919 already amounted to the respectable total of £405.798.—*Ind. Eng.*, Oct. 16th, 1920, p. 219. (J. A. W.)

Abstract of Patent Applications.

16.19. Automatic Welding Company. Continuous tube-mill. 7.1.19.

This application under the title of "Continuous Tube-mill," consists of a mill or machine for the manufacture of metal tubing, and comprises a multiplicity of mechanism which, starting from rolled plate, shapes and welds the same into a continuous tube which may be cut to any desired length.

959.19. The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvents in reinforcement for cement pipes. 26.11.19.

This application refers to specially light and thin pipes (such as are used for ventilation) made of cementitious material by the centrifugal or other process, and proposes to use as reinforcement, material which while being strong and resilient, is of light weight and occupies but little radial space, as for instance strips of cane or sacking, loosely twisted cord, and the like. The reinforcement cage may be constructed by the machine described in the specification of patent No. 494 of 1917

960.19. The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvements in centrifugal formation of socketed pipes. 26.11.19.

This application refers to the manufacture of pipes by the centrifugal process, and proposes, in the manufacture of socketed pipes, to obtain a more or less perfect balance of the centrifugal forces set up in the mould when revolving at high speed, by forming at one operation and in the same mould two pipes, the spigot ends of which meet at a dividing ring in the centre of the mould, the socket end of each pipe being formed at an outer end of the mould.

961.19 and 1020.20. The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvements in pipes and other articles formed from plastic material. 26.11.19.

This application proposes to extend the centrifugal process of pipe manufacture to pipes of particularly light weight suitable for ventilation, also to cartons and similar containers for packed foodstuffs. Plastic materials mentioned are paper pulp, or a mixture of a binding agent such as hydraulic cement or molasses with asbestos fibre or Kieselguhr. The ends of containers may be of the same material, or of metal fitted in known ways. Sheets of material are formed by spinning in a cylindrical mould, the cylinder being finally slitted and flattened out. Any known reinforcement may be used with the plastic material. If a light reinforcement, such as asbestos fibre, tends to segregate to the interior during spinning, an internal roller is introduced to press the reinforcement into place.

962.19. The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvements in forming waterproof pipes of plastic material. 26.11.19.

This application refers to pipes made by the centrifugal process, and proposes to incorporate within the thickness of the pipe a concentric layer of waterproof material such as waterproof fabric, or bitumen. The reinforcement may be incorporated in the outer layer of the material, or in the waterproof layer. The procedure proposed is to form the outer wall of plastic material first, and when this is sufficiently set, to introduce the waterproof material either centrifugally or in any other manner appropriate to the material employed.

The pipe is completed by centrifugally forming an inner layer of plastic or cementitious material in the ordinary way.

963.19 The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvements in reinforcing cement and like pipes. 26.11.19.

This application refers to pipes, columns and the like made of cement and other hardening plastic material, and proposes to substitute for the usual reinforcement of woven wire a cylinder of sheet metal which may or may not be perforated, embedded within the thickness of the pipe. The proposed method of manufacture by the centrifugal process is described.

964.19. The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvements relating to pipes for lining bore holes. 26.11.19.

This application refers to reinforced concrete pipes when used for lining boreholes, and describes a special form of spigot and socket joint formed within the thickness of the wall of the pipe so that both inside and outside surfaces of the completed lining are smooth and without projection. The spigots and sockets are used only as a means of centreing one pipe on the next. The joint between pipes is made by annular flat abutting surfaces.

This application also describes an internal gripping apparatus for the manipulation of borehole lining, consisting of two bodies with *arcuate* gripping edges which are forced apart by a wedge.

6.20. C. A. Parsons. Improvements in packing glands for rotating bodies. 2.1.20.

This application refers to a carbon packing for use in steam turbines and the like, and consists in enclosing or reinforcing the carbon within a frame of metal having substantially the same rate of thermal expansion as the carbon.

634.20. Minerals Separation, Ltd. Improvements in or relating to the Concentration of Ores. 24.6.20.

The above application relates to improvements in the concentration of ores by the flotation process, as described in the applicant's previous patents, 771 and 772 of 1917.

The improvement consists principally in the use of a mixture of permanent gas, such as acetylene and inert gas, such as air, by the use of which it is claimed that both mechanical agitation of the liquid and the use of a frothing agent may be dispensed with, or used only in part.

916.20. E. T. Middlemiss. Improved method of and means for treating finely crushed ores and other material. 24.8.20.

This application describes an apparatus for the purpose of agitating together finely crushed ore and a solvent solution, which consists of one or more vessels, pivotally supported underneath, enabling the vessel to be both swung through a wide angle and rotated on the pivot. The operation consists, after receiving a suitable charge of ore and solution, of swinging the vessel over to an angle of 45° so that the bottom edge rests on a rotating grooved pulley causing a continuous movement of the particles of ore within the solution. The discharge of the treated material and solution is obtained by swinging the vessel in the opposite direction and inverting it over a suitable receptacle.

982.20. P. A. Mackay. Improvements in and relating to the treatment of sulphide ores containing lead and zinc. 3.9.20.

This application relates to the treatment of mixed sulphide ores of lead and zinc, in which the finely ground ore is treated either with concentrated sulphuric acid, containing free sulphur trioxide in solution, or sulphur trioxide in the form of a vapour or gas. No external heat is applied, and it is claimed that the lead is converted to sulphate without altering the zinc sulphide, when separation of the lead and zinc may be effected by gravity or flotation concentration.

999.20. C. A. Blackburn. Binder for Briquettes. 9.9.20.

This application has reference to a binder for various materials, particularly for making coal briquettes.

A mixture of ten parts of molasses, six parts slaked lime, 20 parts fine dust of the materials to be bound, is added to 72 parts of fragments, granules or dust of the material to be bound, with the further addition of from 1% to 5% moisture as required.

The claim is simply for the use of molasses as the main binding agent.

1009.20. E. G. Trobridge. Improvements in buildings and in floors, walls, doors and the like thereof. 9.9.20.

This application refers to the expeditious erection of wooden buildings, and claims the additional advantage for the method disclosed, that green or unseasoned wood may be used and seasoned while in position. In forming an "element" of a building such as a floor, a ceiling, a wall, or even a door, an outer frame is first formed within which boards securely interlocked with tongues and grooves are assembled. A suitable number of the boards composing the element are wedge shaped in pairs, that is to say, two adjacent boards each have one parallel and one inclined edge, the latter lying together as two reciprocal wedges. These so-called "keyboards" are longer than the others, and as drying out or shrinkage proceeds they are driven forward and so tighten up or consolidate the whole.

1014.20. Beswick & Rambush. Improvements in destructive distillation of solid fuels. 9.9.20.

The improvement claimed is the utilisation of a mixture of producer gas and steam for heating the charge to be distilled alone or as well as using external heat.

The apparatus is also claimed and consists of an ordinary producer and an ordinary type of vertical retort, which latter may be separate or placed immediately on top of the producer. There are the usual heating passages, charging hopper, discharging shoot and gas and steam pipe connections.

1019.20. William Henry Stevens. Improvements in the construction of concrete houses and other structures. 11.9.20.

This application describes a method of constructing concrete buildings by means of specially moulded blocks and slabs.

Walls are formed of slabs supported vertically by piers of interlocking blocks. Floors are formed of slabs carried on concrete joists, window and door openings are formed of specially moulded interlocking blocks.

1026.20. Ransomes & Rapier, Ltd., and R. J. Cracknell. Improvements in or relating to rotary pumps or compressors. 15.9.20.

Claim 1 of this application says:—"In a rotary pump the combination with an outer rotary member of an inner rotary member mounted eccentrically therein and adapted to rotate therewith at the same angular velocity, the inner rotary member having two diametrically opposed radial compartments, vanes mounted to slide in these compartments and controlling suction ports therein and outlet valves

in the outer rotary member on the opposite sides of the vanes to the suction ports, the arrangement being such that the volume of fluid drawn in during each revolution is proportional to twice the area of the truncated crescent shaped space between the two vanes when they are at right angles to a line passing through the centres of the inner and outer rotary members.

Other claims are for modifications in design.

1034.20. Hubert Yates. Improvements in anti-creep devices or anchors for railway rails. 15.9.20.

This application refers to devices for preventing the longitudinal creep of railways rails, and describes one consisting of two simple parts, viz., a "clip" of plain flat steel plate of suitable shape to grip the bottom flange of a "T" rail or the bottom bulb of a double-headed rail, and a taper key provided with a large head.

In fixing the device to the track, the head of the taper key is first placed against a sleeper on the side from which it is proposed to prevent creep, with the taper portion lying along the flange of the rail. The clip is then placed in position embracing the bottom flange of the rail and the taper portion of the key, and is driven towards the sleeper by hammer blows on alternate sides of the rail. Tendancy to creep is resisted by the large head of the key abutting against the sleeper. A modified arrangement is provided for steel sleepers.

1046.20. J. W. Stevenson. Apparatus for spraying or atomizing liquids or fluids and heating, cooling, or mixing the same. 20.9.20.

This application describes an atomizer operating on the centrifugal principle. It consists essentially of a cylinder whose diameter is shown from three to four times its axial length. Circular discharge apertures are formed axially in either one or both ends as may be desired. The inlet nozzle (of which there may be one or more) is arranged tangentially, and its width is the axial length of the cylinder.

When fluid under pressure is admitted to the cylinder through the tangential nozzle, it "swirls" or revolves in the cylinder with a velocity proportional to the pressure, the latter being converted into velocity in the cylinder. Fluid is discharged from the axial openings in the ends of the cylinder with a high rotational velocity, the centrifugal force of which breaks the fluid up into spray.

1077.20. Luckenbach Processes Incorporated. Reagent for concentration of ore by flotation and method of making and process of using the same. 29.9.20.

This application relates to the use of a special frothing and selecting agent in the flotation process.

The applicant claims to have discovered that pine pitch converted to a colloidal state by treatment with caustic soda or ammonia and other alkalies and certain oxidizing and fixing agents gives improved and selective effects in the flotation of minerals.

1080.20. H. Bessonet-Favre. Bulton & Paul, Ltd. A new or improved device for raising or elevating liquids. 29.9.20.

This application refers to a device for raising or elevating liquids, comprising in combination an endless flexible non-extensible element such as a chain or cable, a surrounding element or elements comprising a helically wound wire, or a plurality of such helically wound wire helices composing together a compound flexible endless structure, a revoluble supporting pulley at such an elevation above the surface of the store of liquid to be raised as to permit the lower loop of said endless structure to be immersed in said liquid, and means for revolving said supporting pulley to cause the said endless flexible structure to travel, whereby liquid is carried up by the upwardly moving length of said flexible structure and discharged therefrom at said supporting pulley by centrifugal force.

There are other claims which refer to details of construction.

1103.20. A. Rollason. Improvements relating to the production of ammonia. 7.10.20.

This application refers to the production of ammonia from atmospheric nitrogen. The process is mainly as follows:

Air is saturated with steam, passed through a heater, then through a producer filled with incandescent coke; the gases are then cooled and again heated under slight pressure, and then passed through a heated body of coke breeze and lime.

1105.20. H. D. Henderson. An improved mould for use in the manufacture of concrete and other composite blocks for building purposes. 8.10.20.

This application describes a mould for making hollow concrete blocks for building purposes, consisting of two essential parts, viz., the mould proper consisting of a metal frame composed of two vertical sides and a bottom to which are attached the cores, and a removable portion consisting of a false bottom having upwardly extending ends.

Changes of Address.

Bolitho, E. J., *l/o* Florida; Modder "B" School, Modderbee.

Krige, W. A., *l/o* Langlaagte; P.O. Box 5, Maraisburg.

Cullen, Wm., *l/o* Paddington, London; The Crossways, Avenue Elmers, Surbiton, Surrey.

Swinney, L. A. E., *l/o* Perak; c/o Chartered Bank of India, Australia, and China, Penang, Straits Settlement.

Triggs, J. T., *l/o* Johannesburg; P.O. Box 32, Denver.

Wood, A. A., *l/o* Van Ryn Deep, Ltd.; Randfontein Central G.M. Co., Ltd., P.O. Box 1, Millsite.

Associated Scientific and Technical Societies of South Africa.

SCIENTIFIC AND TECHNICAL CLUB.

It is notified that the restaurant in the Club House, 100, Fox Street, Johannesburg, is now open to Members and Associates, and their guests, including ladies.

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

Vol. XXI. MARCH, 1921. No. 9.

Proceedings
AT
Special General Meeting, 19th March, 1921,

A Special General Meeting of the Society was held in the Assembly Hall, Scientific and Technical Club, 100, Fox Street, Johannesburg, on Saturday, 19th March, 1921, at 8 p.m., Mr. James Chilton (President) in the Chair. There were also present:

26 Members: Messrs. F. Wartenweiler, Prof. G. A. Watermeyer, F. W. Watson, C. J. Gray, J. Hayward Johnson, Andrew King, Dr. A. J. Orenstein, John Watson, H. A. White, J. A. Woodburn, Dr. W. A. Caldecott, Jas. Gray, E. H. Johnson, Prof. J. A. Wilkinson (Members of Council), W. Allen, H. E. Barrett, H. L. V. Durell, J. E. Healey, L. D. Hingle, K. Leinberger, E. Pam, T. Proberts, L. G. Ray, W. E. Thorpe, J. T. Triggs and R. Winckworth.

2 Associates: O. A. Gerber and J. H. Watts.

9 Visitors and H. A. G. Jeffreys (Secretary).

The President: I will call upon the Secretary to read the Notice convening the Special Meeting.

The Secretary: A Special General Meeting of the members of the Society will be held in the Scientific and Technical Club, 100, Fox Street, Johannesburg, on Saturday, the 19th inst., at 7.30 p.m., for the purpose of considering certain alterations and amendments to the Constitution and Rules of the Society.

The President: I will ask Mr. Jas. Gray to bring forward the new rules.

Mr. Jas. Gray: As you no doubt recollect, at several of our meetings suggestions have been made regarding alterations to the Constitution, with the object of getting Past Presidents to come back and assist the Society with their experience. The Constitution and Bye-laws have been altered in order to meet your wishes in that respect, and have also been re-arranged in a more convenient form. (The alterations were then outlined.) I beg to propose the adoption of the constitution and Bye-laws.

Prof. G. A. Watermeyer: I beg to second this resolution. We have gone into the question very carefully in the Council. First a Committee was arranged to do the framing; then it was considered and discussed in Council, and it is now for the meeting to decide whether it accepts the amendments or not.

The President: If there is no discussion, I will put the matter to the meeting. Are you agreed that the Constitution and Bye-laws as printed shall form the Constitution and Bye-laws of this Society?

Declared carried unanimously.

Mr. Jas. Gray: The Constitution and Bye-laws having been passed, I move that they come into effect from the 1st June, 1921, which is the beginning of our financial year.

The President: Are you agreed, gentlemen, that these shall come into force as from that date?

Agreed.

Proceedings
AT
Ordinary General Meeting, 19th March, 1921.

The Ordinary General Meeting of the Society then took place immediately after the conclusion of the Special General Meeting.

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 19th February, 1921, as recorded in the February *Journal*, were confirmed.

NEW MEMBERS.

Professor J. A. Wilkinson and Mr. Jas. Gray having been elected as scrutineers in connection with the ballot for the election of new members, the following were declared unanimously elected :—

Barnett, William James, P.O. Box 1809, Johannesburg : Engineer.

Considine, Thomas F., New Prospect Soap and Chemical Works, Denver, Johannesburg : Chemical Works Manager.

Hawes, Elwyn Lamont, P.O. Box 1809, Johannesburg : Mining Engineer.

Pridgeon, Henry William, West Springs, Ltd., P.O. 190, Springs : Mine Manager.

Smith, William Hyde, Crown Mines, Ltd., Johannesburg : Chief Ambulance Officer.

General Business.

THE UNIVERSITY.

Mr. H. A. White: This is a subject that lies close to our hearts; it requires little or no elaborate explanation on my part. The mere reading of the terms of the resolution will, I think, carry your support with them :—

"The Council of the above Society desires to urge upon the Hon. The Minister of Education for his sympathetic and earnest consideration the claims which are now being put forward on behalf of the University College, Johannesburg, for the grant of a charter as an independent and self-contained University. It considers that the work of this Institution in which it has taken a deep interest since its foundation in 1904 completely justifies such a request, and, at the same time, is strongly of the opinion that its grant will open up an even greater career of usefulness to the community and State than has hitherto been possible."

Mr. F. W. Watson: I have much pleasure in seconding Mr. White's motion.

The President: This resolution has been moved and seconded. I shall now call upon Prof. Wilkinson to support it.

Prof. J. A. Wilkinson: In supporting the resolution, briefly outlined the University scheme since its inception.

The resolution was carried unanimously, and it was decided that a copy be forwarded to the Minister of Education.

A RICH NICKEL ORE.

Mr. Jas. Gray: Mr. Andrew F. Crosse at the last meeting drew attention to the occurrence of rich nickel ore at Barberton, and supplied an analysis of the ore in question. An examination of this analysis reveals some discrepancies which require elucidation. The figures show 29·6 % nickel, equivalent to 40·3 % nickel oxide. Two oxides of nickel are known, viz., NiO and Ni_2O_3, the former being found in nature, but a calculation shows that 29·6 % is equivalent to 37·68 % NiO and not 40·3 %. Making the improbable assumption that the nickel is present as Ni_2O_3, the figure would be 41·7 %. Taking the correct figure for nickel oxide together with the undetermined as loss amounting to 1·45 %, a total of 4·07 % remains unaccounted for.

A year ago I made a complete analysis of the ore, and the nickel contents agree well with the figures given, viz., 28·65 %, but the other figures show some variation. My sample contained 10·93 % of silica, 2·43 % alumina, 43·85 % magnetite, 1·5 % magnesia, as well as small quantities of sulphur and arsenic.

As a result of my analysis, I came to the conclusion that the ore was a mixture of nickel oxide, hydrated silicate of magnesia and nickel (garnierite), and magnetite, and this, I think, is correct. At any rate, no facts have been brought forward to refute it.

SYMPOSIUM : MINERS' PHTHISIS

Dr. A. J. Orenstein (*Superintendent of Sanitation, Rand Mines, Ltd.*): Mr. President and gentlemen, considering the importance of the subject and the unusually wide publicity given to this meeting, it is rather disappointing there are not more of us present here; but I have no doubt the weather has had a great deal to do with it. Anyway, those who are present and who have braved the elements are undoubtedly enthusiastic; so we will take their enthusiasm as making up for the absence of other members.

The problem of miners' phthisis is undoubtedly the most important single problem the gold mining industry has to face to-day. Not only is the monetary outlay—direct in compensation, and indirect in preventive measures—so great as to constitute a factor which might be the definite cause of closing down low-grade mines, but, what is even of greater importance, this disease causes premature deaths, sickness with consequent loss of production, and entails so much pain and misery on the sufferer and his dependants, that the combined effect of these more than outweighs even the enormous monetary losses involved.

It is particularly fitting, therefore, that one of the first occasions on which the machinery now provided by the A.S. & T.S. is being put into use, should be for the purpose of conducting a thoroughgoing interchange of views on this arresting problem. It is also most proper that the Chemical, Metallurgical and Mining Society should sponsor this symposium, for it was before this Society that the early papers were read by the pioneers in this field in South Africa.

In my own mind I am satisfied that scattered among the members of the various scientific and technical societies there is sufficient essential information now, which, if focussed and applied, would carry us a very long way on the road toward our goal—the total elimination of this disease. I have come to feel more and more strongly, that our comparatively slow progress has been due to three principal causes :—First : Waiting for a counsel of perfection—for the discovery of *the one thing* to do which would be 100% efficient in preventing miners' phthisis.

Second : The magnitude and the many difficulties of the problem ; the indifference and carelessness of a large body of the underground workers ; the overwhelming burden of routine duties imposed on mine officials ; and last, but not by any means least, the fact that we have become used to the existence of this disease, have engendered a mental inertia, a spirit of *laissez faire*.

Third : We have failed to avail ourselves of the stimulus and other advantages inherent in conferences of large bodies of scientific men who, because of varied training and widely differing daily professional experience with the same problem, view it from various angles. An educated mind has been defined by Spencer, I believe, as a mind capable of viewing a problem from every possible angle. Conferences such as this one can be regarded as the application to the problem in hand of a super-educated mind—the combined reasoning powers and experiences of the engineer, the chemist, the practical miner, the geologist, the medical practitioner, the pathologist, etc. The mental field of each specialist will be expanded and corrected by the light thrown upon it by other workers, and the harvest should be a bountiful one.

Miners' phthisis prevention is essentially a problem the solution of which requires the co-operation of workers in many fields of science and technology. It is only through such co-operation that the problem will ever be solved. I do not by any means refer now to the formation of Committees or Commissions, which have their uses, without doubt, but to constant co-operation, contact and interchange of views and ideas—these flitting flashes of light which come and go, and are forgotten, or are never born except as the product of contact with another mind interested in the same problem. These conferences one confidently anticipates will give the necessary impetus towards discussion, and engender a broader outlook and keener interest, and perhaps—who knows?—give birth to the great illuminating thought which will bring us to the much-prayed-for solution.

I have said that one reason for our comparatively slow progress in combating miners' phthisis has been the mental attitude of waiting for the 100% efficient preventive measure. It should ever be borne in mind, however, that the history of preventive medicine teems with instances of brilliant results achieved by the simultaneous application of a number of measures, each of but low efficiency.

One need not go far afield for an example of this—it is at our very doors. In 1910 the death rate from all diseases among the natives on these mines was about 35 per 1,000; in 1915 it was about 13 per 1,000; in 1920—about 11 per 1,000 (excluding deaths due to the epidemic of influenza prevailing in the last three months of the year). Such an achievement in one decade is without parallel, so far as I am aware, in industrial hygiene, and it is due not to one perfect preventive measure, but to the combined effect of many measures, any one of which by itself, is of very low efficiency indeed. It has been said that the great reduction in the pneumonia death rate is the deciding factor. *That is not so.* If pneumonia were altogether eliminated, and other causes of death remained as they were in 1910, we would still have a mortality of 22 per 1,000, instead of 9 per 1,000, as was the case in 1920. This means a potential saving of about 2,600 lives in 1920 alone, achieved by applying a large number of safeguards, no single one of which is of very high efficiency.

I therefore commend to you the careful consideration of the possible value of applying as many as possible of the known, even though admittedly imperfect, safeguards, and not to wait discouraged because the perfect panacea is not to hand.

This conference is eminently fitted to

consider our present problem. I venture to say that nowhere on earth is there a body of men more fitted for this task. I look very hopefully to the fruits of our deliberations, and I sincerely beg you—all of you—to take part in the discussions and to get your friends to come to these meetings and participate in the conference. This symposium, I hope, will take many meetings—we must not hurry over it—and we must hear everyone who has anything to tell us. Every ray of light thrown upon this problem is very precious. No matter how slender and hesitating your beam, do not fail to throw it on our minds. We want it so very badly, for the sake of the pitiable human wrecks we may prevent.

Dr. A. Mavrogordato (*Research Fellow on Industrial Diseases, S.A. Institute for Medical Research*): Mr. President and gentlemen, I thank you for the honour you have done me in inviting me to join in this discussion. The part I have decided to speak to you about this evening is the influence of the different kinds of dust on chest diseases. It has always been recognised that different dusts produce different effects. Some produce miners' phthisis, and some do not.

The work on which I started was, trying to determine why different dusts were, some harmful, some more or less harmless. The point was of importance in connection with "stone-dusting" in coal mines. I propose starting by showing what happens to the dust when it is inhaled.

There are certain cells in the body whose function it is to act as scavengers, when any small foreign particles—living such as bacilli or non-living such as dust—make entry, these cells are produced in large numbers and take up the invaders. Were it not that the life of these cells is short and that they are rapidly removed they would fill up the organ they are trying to defend, and its last state would be worse than its first. When dust of any sort gets into the lung these cells are produced and take it up but after this initial response, as far as my own experiments go, I have noted three different reactions according to the type of dust.

(a) Coal is taken up with avidity but does not influence the life history of the cell; if anything, the coal-laden cell dissolves more quickly than the empty cell. Most coal dust is found free in the lung, and can get out, and it is the dust that stays in that matters. With coal there is a steady drift out of the lung which keeps up with rate of invasion in moderate doses.

(b) With certain hard stones, such as Derbyshire gritstone, the cells that take up the dust are, to some extent, preserved, and most of the dust is intra-cellular and thus anchored in the lung. The preservation is not very great, the cell appears to be protected from autolysis (self-digestion), but not from digestion by the tissue fluids. The cells persist for some time as long as they remain attached to the surface of tissues like adhesive stamps to envelopes, and one sees them scattered all over the lung. The organs of the body, like houses in a town, have services in common, *e.g.*, drains. These are known as lymphatics, and the excess of scavenger cells gets away through them; they either dissolve in the contained lymph or are deposited in receptacles known as lymph glands. Both coal-laden and stone-laden cells get into these lymphatics and there dissolve or get to the lymph glands.

(c) With free silica the preservation of the cells is more perfect; not only are they protected against self-digestion but also against digestion by the lymph. The result is that they accumulate in the lymphatics and block them. I have not observed this phenomenon with other dusts. There is another peculiarity in silica-laden cells, instead of remaining separate they tend to aggregate together in little masses. I have not noticed this behaviour to any extent on the part of the cells laden with other dusts. It is in the free aggregates of cells and in the accumulations in the lymphatics that the fibrosis starts, and it is from such foci that it spreads.

The silica dust does not appear to produce fibrosis directly; one notes three stages: (1) The dust provokes the scavenger cells. (2) These cells collect together into small masses. (3) The small masses are fibrosed. This accumulation of cells into masses appears to me to be a necessary preliminary to fibrosis on a considerable scale when dust is concerned.

Coal miners are singularly free from lung complaints, and although plenty of coal miners are exposed to free silica such men seem to be no worse off than the others. It appeared possible that the outward drift set up by the coal might play some part by carrying off the silica with it, and I have performed several experiments with exposure to coal and silica. If the coal be given with the silica or immediately before the silica, under experimental conditions, it

helps the silica out, but if the silica be given before the coal, it interferes with the lungs' ability to rid itself of coal. Once the silica has been anchored in fixed cells coal does nothing, but it does appear to arrest its fixation.

Dust is not the whole story in miners' phthisis. A house with obstructed drains is unhealthy, and an organ with blocked lymphatics has diminished ability to deal with infections. The dust in the mines here has now been so reduced that I doubt if enough is inhaled to produce direct disablement due to dust alone, but enough damage is done to the lung to interfere with its ability to deal with ordinary infections. It is because I have found dust blocks in the lymphatics of men who have worked only a few years underground and have died of some complaint in no way related to dust and with no signs or symptoms of lung trouble, that I think that efforts should be made to further reduce the dust.

Now, the coal miner, as far as respiratory diseases are concerned, is about the most favourably placed of anybody, with the exception of the agricultural labourer. One factor in that is perhaps the way coal acts, as I tried to show you just now; but this is nothing like the whole story. In many of the coal mines at Home, where you have the seam at steep inclination, you are going through various rocks; for instance, we have shales containing up to 40 % of free silica, and the dust in the air contains up to 12. Here you take all sorts of precautions to keep down the dust, while in coal mines none are taken, and the free silica blown out of a coal mine to-day may be about equal to the free silica blown out of a mine of the same size here.

If you want to see dust in a coal mine, go in the main road when the shift is coming on or off; you cannot see your hand before your face; but, if you go on to the working face there is very little dust to be seen, because it is being blown away as soon as it is made. Here the main roads are about the least dusty places on the whole mine; where you get the dust is at the working places where the men are gathered together. It is this reverse distribution which I think is a great factor in helping the coal mine. You get the three factors: the brisk air currents at the working place of the coal mine; both blow the dust away and dilute the concentration down to a comparatively small amount; and, perhaps thanks to the action of coal on the lungs, the small amount of silica inhaled under these circumstances, can be dealt with. If you go back a generation before the ventilation of the coal mines, you will find you had "anthracosis," a disease which has practically disappeared in modern times in British coal mines. It is these three factors, I think, which account for its disappearance.

Now, here, wonders have been done, I think, in the way of dealing with the dust, in the organisation of the wet process and keeping track of the various sources of dust and in the invention of dust determining instruments. But you are in the same boat as we were. It is nearly 200 years since Duncan introduced the wet granding process; for 150 years we worked with that. The wet process altered the whole conditions and improved them, clearly; but it did not get the last lap; we have only finished it, I think, recently, by adding to the process the use of "hoods" and down draughts. I think you have done wonders with the wet process; but there is still too much dust. You have to do something more for it in addition to the wet process. I see only two ways: one is dilution of the dust that cannot be avoided, by blowing air and shifting it from where men are to where they are not; and the other way is by trying something analogous to the hood and down draught on the grinding wheel. I do not think the last word has been said on the subject. Dr. Orenstein said you must not turn a thing down because it does not give 100 efficiency. I do not think you can put a contrivance on a drill which will stop it making dust under any circumstances; but the trouble with the drill is not the fact that it makes a little dust perhaps all the time it is running, but for a few minutes at a time, when it goes wrong, it fills the place with dust; and if this occurs in a stagnant place, the rest of the shift is going to work under bad conditions. I think one may be able to devise something which, while it will not stop dust production altogether, will stop the drill at the moments when the water service has gone wrong, from shedding enormous quantities of dust into the air. I do not despair of some way being found out of the difficulty. Anyway, Mr. Pam and I are going to try and find some way out of it. If you had no dust there would be no miners' phthisis. But it is not the dust alone that does it. You are no longer getting here the type of miners' phthisis you formerly had. I am a

new-comer here; but I saw the ravages of the disease twenty years ago when men came back to Cornwall, after working on the Rand. The dust is the first factor. The second factor is the effect of infection on the dust-invaded lung. So the first step to go for is to get rid of the dust, either by dilution or a dust-catcher, and then after that to consider what means one can have of diminishing the chances of infection.

If you take the list of diseases of respiration in mines, you get the coal miner at the top, and the Rand miner at the bottom. I do think, if you can devise some means of keeping down the dust, you will put him well away up; put him up to the level of the ordinary metalliferous mine worker anyhow.

Engineers tell me it is not practicable here in many cases to get the dilution of the dust by blowing the air currents past the working places like one does in a coal mine. That I am not competent to discuss. If it cannot be done, it cannot. But it is certainly the method to aim at. The air current which dilutes the dust is going to cool your hot mine. If you have got hot air moving it is going to make the place so much the more pleasant than hot air which is still. That is the way to deal with it when practicable. Where that cannot be done, the next thing is to invent a dust-catcher; if not, you must try some other method. I think the wet process has done wonders; but I think you have to get something more on the top of it.

REFERENCE TO PLATE, PAGE 163.

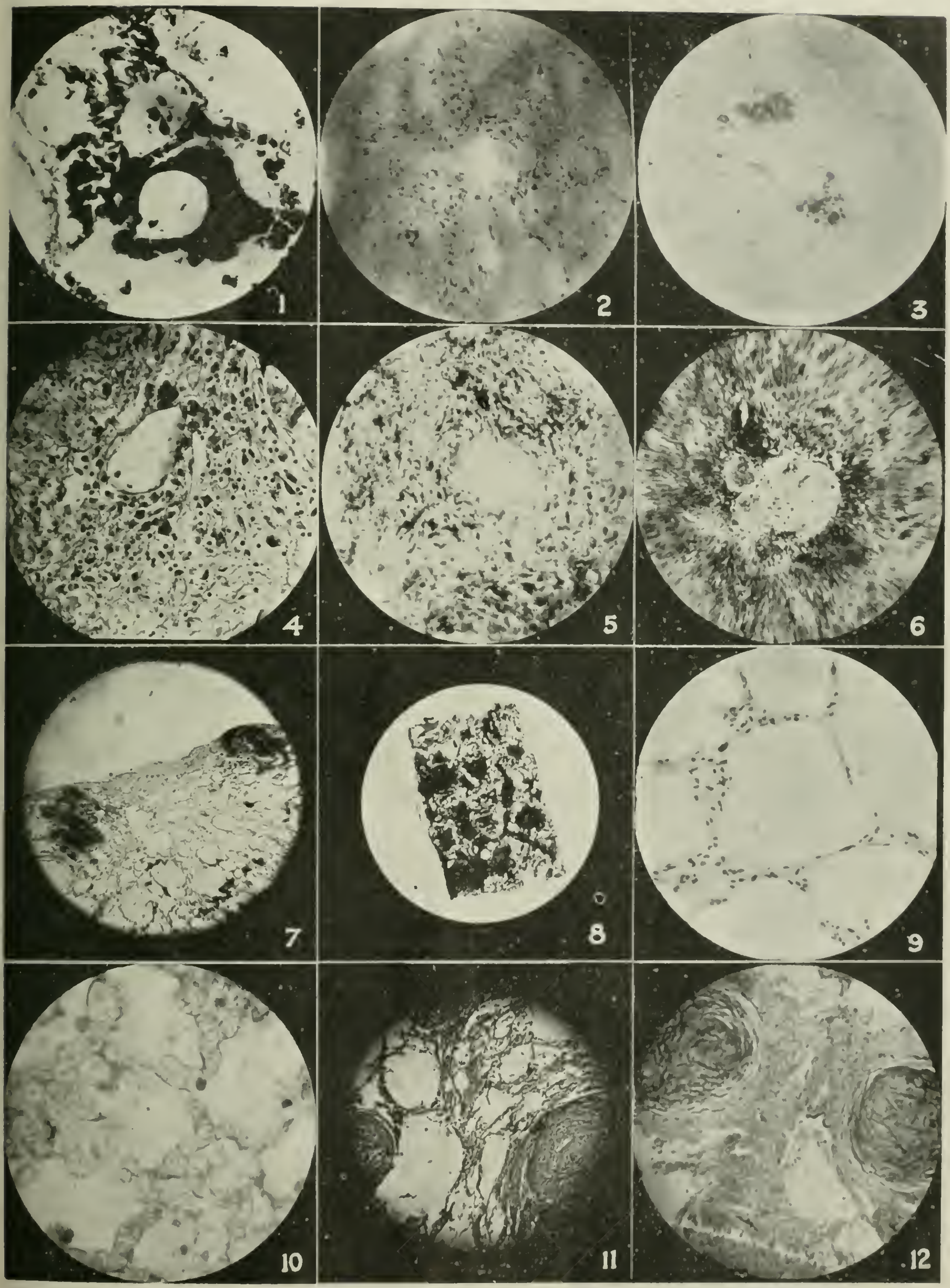
1. Lung invaded by coal dust; the dust is mostly extra-cellular.
2. Lung invaded by grit-stone: the dust is intra cellular and the cells scattered.
3. Lung invaded by free silica; the dust is intracellular and the cells clumped together; these cell clumps will be fibrosed and form pseudo tubercles.
4. Dust laden cells in perivascular lymphatic.
5. More advanced stage of above, the retiform fibrils have become coarse white fibres.
6. Final stage, the whole blood vessel with its mantle of lymphatics is converted into a solid rod of fibrous tissue.
7. Pleural pseudo tubercles resulting from fibrosis of clumps of silica laden cells which have drifted there.
8. Advanced simple silicosis resulting from the combination of the processes illustrated in photos. 3 to 7.
9. Lung after brief exposure to small quantity of baked road dust. One or two dust-laden cells are visible, otherwise it is normal.
10. Lung after similar exposure but to unbaked dust. The dust is infected and the lung has reacted to the infection.
11. Portion of No. 8 enlarged: note that fibroid nodules pass direct into ordinary lung tissue.
12. Infective silicosis; the fibroid nodules are surrounded by granulation tissue due to infection.

Mr. C. J. Gray (*Inspector of Mines, Johannesburg*): Mr. President and gentlemen, I have listened with very great pleasure and interest to the address which has just been given by Dr. Mavrogordato. I am sure it has greatly added to our knowledge of the medical aspect of the question. I am also interested to find he has dealt with the question of prevention very much on the same lines as I have independently dealt with it, in the short contribution which I now propose to read on what remains to be done to prevent miners' phthisis.

Though immense amounts of thought, work and expenditure have been devoted to prevention of miners' phthisis in the mines of the Witwatersrand, and great progress has been made, the disease is still very serious. As those who do not know the facts are tempted to assume that all that is possible to deal with dust underground has been done, it may serve a useful purpose if I point out some of the respects in which present conditions and measures are open to improvement. While the question as to what can be done is dominated by economic considerations, and it may be impracticable to make profit or avoid loss at a particular mine and at the same time do all that is desirable, even at such a mine clear recognition of how and where safeguards are weak may result in improvement.

Probably the human factor will be dealt with specially by other contributors to this discussion, but there are a couple of points to which I wish to draw attention.

Some officials, many men and most natives, though they know that dust is dangerous, do not realise fully that the danger is from air-borne dust which is quite invisible to the unaided eye, and of which the senses may give no indication. They also fail to realise the conditions under which such fine dust is formed or accumulates in the air. If we had in every miner's hand a simple detector for dangerous dust such as



For description, see page 162.

the safety lamp is for firedamp, knowledge would soon become general; in its absence propaganda on the lines of the "Safety first" movement, lectures, informal instruction by officials and extended use of and demonstration with the Konimeter are desirable.

Human nature being what it is, the common systems of payment on economic results tend to neglect of phthisis precautions. The white man is tempted to permit "lashing" or drilling when the water supply is off or defective in pressure if his pocket will suffer through delay, and the native who fears that he will get a "loafer ticket" or lower pay for failure to drill his full number of inches, is similarly tempted. Dry drilling or lashing is usually due to fear of loss of time from failure of the water supply. If a contract, bonus or task system is to be maintained, discipline alone should not be relied upon, but so far as practicable, by such measures as providing machine drills which will not work without adequate water supply, wrong-doing should be made difficult.

Ventilation, if not the most important factor in phthisis prevention, is certainly one of the most important, and much is to be gained from its improvement. If silica dust causes miners' phthisis, a badly ventilated mine, other conditions being the same, must produce more phthisis than a well-ventilated mine.

The problem to be dealt with in ventilation of a phthisis mine is very similar to that of ventilation of a fiery colliery. In a colliery, issue of firedamp cannot be prevented, but safety is attained by providing such an air supply, and so distributing it, that in each working place, the firedamp is sufficiently diluted to be harmless. Care is taken that a single air current circulates through a small number of working places only, so that at the last it is still harmless despite accumulation of firedamp in it from other places. In a phthisis mine much can be done to prevent the issue of dust into the air, but in practice some must issue. When once suspended in the air, the dangerous dust, which is so fine that it behaves very like a gas, is swept along in the air current. To make it harmless it should be dealt with like firedamp: sufficient air should be provided to dilute it, and the dust-charged air so distributed that there should be no excessive accumulation of dust in the air breathed in any working place.

Though the principle just stated is not modified thereby, I should mention that we are so fortunate as to have a means of taking dust out of the air current which is not available for firedamp. I refer to water sprays and atomisers, which though not very important directly, being unreliable and inefficient, are sometimes important indirectly, as they enable the air to take up moisture. If dust-laden air in the lower workings is nearly saturated it will, as it rises higher and therefore falls in pressure and temperature, deposit some of its moisture as mist. As the water globules in the mist form round dust particles, they weight the dust and cause it to settle. That action having taken place, the air may be considered as fresh air for dust dilution purposes in workings above, though not "fresh air" as contemplated by the Mines and Works Regulations.

Ventilation on the Rand is far short of fiery colliery practice. Generally the total volume of air circulating in a Rand mine per minute is much less than would be required for a colliery with a similar number of underground employees, but comparison with regard to the distribution of the air is still more unfavourable. The long inclined downcast shafts, with their numerous connected levels or crosscuts which are usually closed off by single ventilating doors only, are very poor main airways. The doors are often leaky, and not infrequently they are propped open. After the air leaves the shaft there is generally practically no attempt made to control its distribution. Much of it shortcircuits up through stopes which are not being worked, part only serving working stopes, while very little gets into the development ends, most of which are ventilated during the working shift only intermittently by the compressed air supplied to machine drills. There is practically nothing which corresponds with the steppings and brattices used in fiery collieries to lead the air up to the faces of headings and other working places. Practically nothing is done to split the air currents into satisfactory ventilation districts, and I have never seen an air crossing in a Rand mine, though there are a few on the East Rand.

Of course there is a reason for the present position. It is past failure to realise fully the importance of ventilation as a factor in dealing with the dust evil. In the recent past it was considered that apart from special places the ventilation of the mines was generally reasonably good, the tempera-

ture and the percentage of CO_2 allowed by the regulations being alone taken into account. The mine workings have not been laid out with a view to good ventilation as ventilation must now be judged, and to provide a really good system for an old mine is often a very difficult and costly matter. Much has been done, especially in the newer mines, in recent years, and if the position is still far from ideal it has markedly improved compared with what it was.

I consider that ventilation conditions could be further improved in many mines if the following measures were more widely adopted:—(a) Substitute stoppings for doors on levels which are permanently or temporarily out of use. (b) Limit the number of levels for tramming to the shafts by concentrating hoisting at particular levels and lowering rock to those levels by self-acting inclines or otherwise, through stopes or winzes—avoid ore passes as much as possible. (c) Double all ventilation doors and make them all self-closing. (d) Place doors carefully where they will be as free as possible from crush or other damage, and where they will not be kept open by standing trucks. (e) Lead the ventilating current out to the working stopes by closing off passage through old stopes nearer the shaft by sand-filling or packs. (f) Regulate the amount of air passing through working stopes which get an unduly large proportion, by constricting the air passage, or, preferably, where possible, by making an easier passage for the air passing through those stopes which get an unduly small proportion. (g) Cause the air current to follow the stope faces by closing passage through the centre of the stope by continuous stulls or packs. (h) Provide airways into working stopes apart from boxholes which may be partially or completely blocked by broken ore. (i) Make development places beyond the air current as short as possible, and provide good auxiliary ventilation in them; preferably by electric fans. (j) Provide good auxiliary ventilation in all sinking shafts.

The water service for dust allaying is a feature of Rand practice for which credit can be taken. The idea of applying water and preventing dust being formed is an excellent one, and at first sight at least far better than dealing with the dust by ventilation. Undoubtedly the water services have done much to reduce miners' phthisis, and any diminution in their present efficiency is not to be contemplated, but they are not and in my opinion never will be, adequate alone to cope with the danger. The water supply to all working places involves a most elaborate and extensive system of dams, settling pits, steady heads, pipes, etc., and under mine conditions the risk of interruption, reduction or fouling of the supply is great. Silting up of dams, blocking of pipes by incrustation or by sediment or air lock, breakage of pipes by corrosion or injury from trucks or rock movements or blasting, and undue use or wastage of water by individuals are ever recurring troubles. It is often found on visits of inspection to working places that temporarily there is either no water supply or a supply which is deficient in cleanliness or pressure or in both. The efficient use of water to keep down dust if the supply is available, requires the constant and conscientious attention of both whites and natives, and often the sacrifice of their personal comfort or perhaps even health. Standing in water, sitting on wet rock or working under a spray is not very desirable, and the temptation to be sparing in use of water is often given way to.

Recent investigation has shown that the water blast *as used* is a very poor safeguard. Even when it is working properly the force of explosion of the shots will drive fine dust through the spray from the water-blast, but in practice the water blasts seldom work properly. Individual water blasts will work well when tried during the working shift, but when all in the mine are open at blasting time and air pipes in winzes, etc., are blowing, there is often insufficient compressed air to supply them all, and they fail hopelessly. Therefore when the "lashing shift" goes into development places the approaches to the faces often are not cleared of dust and at the faces, though the compressed air from the water blast may have cleared away fumes and dust, the broken rock is dry and dust is raised in watering down.

To improve matters I should recommend:—

(a) More attention to the settling and filtering of water so as not only to remove silica particles but also those deposits which may be formed in the aeration or neutralisation of water supplies. (b) More careful neutralisation and control over the contents of the water, so as to avoid corrosion or incrustation of pipes, etc., and early replacement of corroded or incrusted pipes. (c) Greater care to ensure that main pipes are of ample size so that they will allow the required flow without undue friction when

the use of water is at its maximum. (d) Greater care in the placing and protection of water pipes. (e) Extended use of water (not air) fed machine drills. (f) Greater care in placing sprays and atomisers so that they will not wet persons unnecessarily. (g) Attention to the drainage of development ends so that water will not accumulate there. (h) Use of water blasts which are economical in compressed air and will work with air at low pressure.

Though improvement may be made I think that when owners and managements have done all possible with regard to use of water there will still be frequent failures to prevent formation of dust. The simplicity and constancy of action of a good ventilation system can never be obtained in the use of water and therefore it is important to back the use of water by ventilation.

While in this contribution to the discussion I have confined myself to the question of dealing with silica dust I recognise the importance of further investigation of the conditions under which persons become sufferers from miners' phthisis and also of the conditions under which, though exposed to silica dust, persons may be more or less immune. Research may bring new discoveries of the greatest importance in control or prevention of the disease, but in the meanwhile it seems wise to press on as in the past with the fight against silica dust. We are now aided by new weapons and knowledge, and can reasonably hope that the success of the past will be surpassed by that of the future.

Mr. Lionel Harris (*Secretary, Underground Officials' Association of South Africa*): In recent years the notable lack of technical recruits to the ranks of the underground staff calls for special comment. At first the war was blamed for the shortage of men undergoing technical training, but no improvement has taken place since the war ended, and the time has arrived for the serious consideration of what is required to attract more young men to the profession of mining engineering.

No doubt the fear of miners' phthisis has deterred men from becoming mining engineers in this country, and the initial examination by the Medical Bureau under the Miners' Phthisis Act prevents men from other countries coming to South Africa when there is a risk of being turned down at the Bureau.

Inquiry in other countries will probably show a similar falling off in mining students, and although miners' phthisis will not be blamed it will be found that the unhealthy condition of the mines has brought about a fear similar to that existing in this country, although it is not called "miners' phthisis."

Although these fields are sufficiently extensive to have a class of people specially devoted to mining, such as exists in the coal mining areas of Great Britain, we find that the reverse is the case, and that mining men take every care to prevent their children becoming miners. Recruiting of experienced miners from overseas is similarly prevented by the same reasons that apply to technical men.

It must therefore be in the interests of the industry to pay more attention to the health of its employees, and steps taken now may prevent the present serious problem of the shortage of efficient whites applying in time to the natives.

The Underground Officials' Association is particularly interested in the official staff of the mines, and the lack of trained men here is probably due to more reasons than the fear of miners' phthisis.

The fact that qualified men, holding diplomas or degrees in mining engineering, have to pass examinations to obtain the Government certificate of competency, enables untrained men to get four years of practical experience before the trained man starts actual mining, and so to get the all-important certificate earlier; he has the additional advantage of gaining the practical experience.

Probably it is correct to state that the trained man obtains the Government certificate at first attempt, whereas the others may try several times before succeeding.

Beyond an examination in law there seems to be little reason or justice in compelling qualified men to obtain these Government certificates, and local institutions would benefit if the anomaly were removed.

There can be little doubt that the profession of mining engineering, while probably one of the least healthy and most arduous, is also the worst paid, with the result that trained men are almost unobtainable.

The effect of this on the industry is being felt to-day, and, with the large wastage that is taking place, will tend to become still greater in future.

We are glad of the opportunity afforded by your Society of drawing attention to a state of affairs which though hardly covered by the heading "Miners' Phthisis," may be attributed to that disease to a very large

extent, and we contribute a note on the inspection of underground health conditions.

A NOTE ON THE INSPECTION OF UNDERGROUND HEALTH CONDITIONS.

The health of the workmen is of importance in any industry, second only to the existence and value of the product.

In mining the conditions cause the problem to be of more than ordinary importance, owing to time lost in proceeding to and from work being subtracted from ordinary working hours, and the difficulty of supplying extra men to make up working time lost owing to absence due to ill-health. The health problem, too, becomes more complex and more varied in mining.

The supply of good air to working places was one of the earliest difficulties in mining; and the difficulty has been renewed with changing methods by the introduction of explosives causing noxious gases, and by the necessity of dealing with explosions of gases and coal dust. Here quantity and quality of air were the primary points to be watched.

Exposure of workmen to sudden changes of temperature on starting or leaving work or on moving to different parts of the workings became suspect and many diseases are now considered avoidable.

Nowadays, with the spread of knowledge, diseases such as silicosis, tuberculosis and pneumonia are being guarded against by adequate ventilation and disinfection, and the effects of moisture and temperature of air are being studied.

When the depth of workings made it difficult to come to the surface during a shift, a supply of clean water for drinking purposes was provided and sanitary conditions generally came under scrutiny.

All these factors render the control of conditions difficult, and a great deal of special knowledge is demanded of those who have to deal with the matter, and there appears to be room for co-ordination of the various aspects of health inspection under a single head on each mine. The present state of affairs is confusing, and the large variety of ways and means adopted does not tend to efficiency, besides making it difficult to apply methods—successful on one mine—elsewhere.

We have dust inspectors on most mines varied by air inspectors and air and water samplers. In some instances the work is done by native supervisors, mine samplers, or assistant surveyors, indicating a perfunctory system and suggesting that the work is done as a routine and not considered important. There are ventilation inspectors on some mines, men of somewhat higher attainment as a rule.

One or two mines have certificated sanitary inspectors; on others this work is performed by native boss boys.

No uniformity exists either of practice, or perhaps of idea.

All these officials have the single object of improving health conditions, and, if a competent underground health inspector were appointed, some of these officials, who are not too highly qualified, would find themselves with a head to report to, who could instruct them in their duties and make them of real use.

The branches of a subject now various and complex would be reduced under a single official and experiences could be spared: matters now apparently heterogeneous might prove identical, increasing beneficial effects, and rendering useful expense and effort now wasted.

The President: Are there any representatives of the South African Mine Workers' Union present? If there are, we should like them to contribute to the discussion. Or of the Mine Managers' Association?

Mr. E. Pam: I think I would rather make no remarks to-night, as I have not prepared a contribution for this discussion, but I hope to do some work along the lines proposed by Dr. Mavrogordato, and to make a contribution to the discussion at a later date.

I trust also that the Mine Workers' Union will send a representative to one of the meetings on this subject, in order that we may hear their point of view."

Mr. H. A. White: There are one or two points I should like to bring to the notice of this meeting. In the first place, it seems to be admitted that a thorough application of all the already known methods will not, in themselves, solve the problem completely. I think that seems to be agreed. It is obvious, therefore, that we shall have to do something more in the way of research than we are doing at present. We might have a Research Committee appointed by the Government, consisting entirely of specialists, a physician, physicist, a chemist, and an engineer, and those gentlemen should have no routine duties of any sort whatsoever to perform, but their whole time should be devoted to research in connection with this vital problem.

There is one thing to be noticed, that is,

on all the Safety First Notices to be seen at the mines. I have never yet observed any advice to miners to breathe through their nostrils. Dr. Mavrogordato's contribution commenced by omitting any notice of that little precaution entirely. I do not know whether the doctors agree it is necessary, but I have always been led to believe it is wise in a dusty atmosphere to breathe through the nose. I think that might be emphasised on all our Safety First Notice Boards.

There are two contributory minor causes which I have never yet heard mentioned. I believe on the Witwatersrand mines the average depth is 2,800 feet odd: on some of the mines we have workings at 3,000 or 4,000 feet. In bringing men up from the shaft they are brought up to a 10% decreased pressure of the atmosphere, in a few minutes. That means that the nitrogen in the blood to a certain extent must be released; now, it is not released to such an extent as to cause anything like mountain sickness or caisson disease; but still, there may be some effect. When that rapid alternation is carried on day after day it may have some cumulative effect upon the miners subjected to it.

The other point is this, that in rock drills in use on the mines quite a large amount of oil is used. This oil is mineral oil, and it therefore cannot be chemically acted upon by any substance present in the blood of the lungs, and the people actually mining are exposed to a fine mist of this oil; surely it must have some effect on the lungs. Possibly a different form of lubrication might be advantageous.

The President: Gentlemen, the Symposium will be continued, and we sincerely hope that the high character of the discussion will be kept up. I am sure that great good will be done before the end of this discussion is reached.

Dr. A. J. Orenstein: On Thursday, the 14th April, Dr. Mavrogodarto has kindly promised to read a very extensive paper dealing with practically the same subject, before the Witwatersrand Branch of the British Medical Association, in this hall, and to which they are inviting all the other Societies associated here. As we cannot send notices to individual members of all the Societies, I am taking this opportunity of inviting you, on behalf of the Witwatersrand Branch of the British Medical Association, to their meeting at 8.15 p.m., on Thursday, the 14th April.

THE KATA-THERMOMETER AND ITS PRACTICAL USE IN MINING.

By H. J. Ireland, M.B.E., A.M.I.C.E.

(*Printed in Journal, November, 1920.*)

DISCUSSION.

Dr. A. J. Orenstein: I should like to make one remark in connection with Mr. Gray's contribution appearing in the last issue of the *Journal*. I hope I am not misquoting him; but, as far as I remember, he said the Kata-thermometer must be used with great care, or you might forget the fact that the stirring of air may result in the raising up of dust which is precipitated out, and this dust increase the danger of miners' phthisis. I presume this was based on the idea that the Kata-thermometer would give a comparatively good reading whether fresh air was introduced or whether the local air was stirred up, assuming other conditions being more or less equal. I would like to join issue on the point of danger of stirring up air by means of a local fan as being an added danger in the production of miners' phthisis. I think if the local fan were properly placed and properly used, it would carry out a most useful object in the prevention of miners' phthisis. The single experiment we performed—a very short one—with the use of a local fan, simultaneously with the taking of air samples, certainly did not indicate that the local dust increased; if anything, it indicated it was decreased. Furthermore, if the local air was stirred up in such a way as to direct it away from the face, it would be one of the methods we might assume as being of benefit in the reduction of miners' phthisis. I do not think that the use of the Kata-thermometer, therefore, is likely to lead us into the perpetuation of bad practices simply because it might stimulate us to use local means of producing air circulation. I hope that at some future time in the discussions at this Conference on Miners' Phthisis this particular problem will be tackled more thoroughly. There are devices on the market now which can be economically used for the local stirring up of air; thus improving the local atmospheric conditions so far as general health and working efficiency are

concerned which to my mind is important, and which would really be the means of reducing the local dust content of the air at the actual working place, where the dust does most harm. The whole point of my remark is—Mr. Gray's danger signal from one point of view is called for; but from the practical point of view—so far as our knowledge goes to-day it need not be taken as being a very serious danger.

Mr. C. J. Gray: Dr. Orenstein may have slightly misunderstood my reference to the matter. I have said this evening that the ventilation of development ends by fans is a desirable thing, which is not consistent with an idea that I deprecate the use of fans for moving the air in development ends or close places. What I do hold is that simply circulating the air in a particular working place without introducing fresh air and without clearing out the dust-laden air would be a mistake. If you had a development end far in, and you stirred the air round in the end and did not bring in any fresh air so as to carry out the dust-laden air, you would have an undesirable state of affairs, although because the stirred air, being in motion, would have a cooling effect, the Kata-thermometer might give good readings.

TREATMENT OF ANTIMONIAL GOLD ORE AT THE GLOBE AND PHŒNIX GOLD MINE, SOUTHERN RHODESIA.

By V. E. Robinson.

(*Printed in Journal, January, 1921.*)

DISCUSSION.

Mr. G. W. Dimond: The paper on the above by Mr. V. E. Robinson contains many points of interest, and it is a pity that he has omitted to give further details.

One would like to know the percentage of stibnite that has to be dealt with in the cyanide plant since it is obvious that with such a system of close concentration, a large portion of this mineral will have been removed in the form of concentrate together with pyrites and galena if any.

The description of the treatment and the behaviour of the tailings would lead one to the opinion that the pyritic material was marcasite (FeS_2), which very rapidly changes to ferrous sulphide ($FeS + S$), and which, owing to its power of absorbing oxygen, lowers the dissolving power of the solution, and very possibly decomposes the $KAuCy_2$ so as to precipitate the gold already dissolved.

Thus if a vat of current sand under treatment as in Mr. Robinson's Table I. had been sampled in sections of, say, 12 inches from top to bottom, I think it would have been found that the top 12 inches would have shown a good extraction but the bottom 12 inches would have contained a major portion of the dissolved contents of the vat, which had been reprecipitated.

Table I. does not exactly demonstrate the necessity of "weathering" the tailings before treatment since the two tests were not identical, one being conducted with 2 lbs. of lime per ton and the other without any lime at all. This latter with a marcasite ore would give rise to a formidable amount of ferro-cyanides, and also form hydrates detrimental to good precipitation.

My first experiences with the ore of the Jessie Mine, Bulawayo District, showed almost identical results with regard to the necessity of "weathering" the tailings, and a very poor extraction was obtained both with and without alkaline treatment if the tailings were not oxidised sufficiently, *i.e.*, until the change of colour to yellow.

Continuing the experimental work, however, I found that by crushing in a strongly alkaline solution of cyanide, 0·1% KCN 0·02% CaO, and direct filling into sand tanks, and by taking great care that no oxidation of the tailings took place (*i.e.*, at no time during treatment were the tailings exposed to the air) that an extraction of 90% on a 7 dwt. ore was possible.

On rearranging the plant to admit of this new treatment, I found that 10% leached sufficiently well to remove the soluble gold, and thus no slime plant was necessary.

This process has now been in use for five months and has proved most satisfactory.

The greater proportion of our gold is coated with iron salts, and the cyanide removes this coating and renders the gold amenable to amalgamation, and this may be the case with the barrel treatment described by Mr. Robinson since cyanide acts but very slowly on sulphur.

REMARKS ON BULLION SAMPLING.

By H. R. S. Wilkes.

(Printed in the Journal, November, 1920.)

CONTRIBUTED DISCUSSION.

Mr. R. R. Kahan: The writer has read with interest the remarks made by Mr. Wilkes and others on the above subject, at the Society's meeting held on the 20th October, 1920.

It is with considerable surprise that one learns that amongst assayers' troubles are those due to "errors in describing the bars and their samples." Errors due to misreading the assayer's report or calculating the gold content of a bar are in the same category. In any well-conducted institution these should be eliminated.

The assayer has plenty of opportunities to make mistakes in the assaying operation without being made to "tremble in the manager's sanctum" for the mistakes which are not of assaying, unless it be that the assayer is responsible for the melting, sampling and evaluating the gold bullion, in which case it is the assayer-melter-clerk person who should be blamed.

Now for the points mentioned in the discussion at the last meeting of the Society.

Sampling.—The three methods commonly employed are:—

(1) Dip samples.

(2) Clip or chip samples, and

(3) Drill samples.

These samples may or may not truly represent the bullion sampled for the following reasons:—

Dip Samples. If the bullion is melted at the correct temperature and properly stirred the dip taken should represent the mass of the bullion, provided the bullion is poured immediately after dipping. This is important in order that there should be no time for further refinement of the bullion by the fluxes or reduction of oxides by the plumbago crucible. The dip sample may not represent the mass of the bullion because compared to the resulting bar of bullion the dip has a large surface and so oxidation has a greater effect on the dip than on the bar during the time that elapses before quenching. Again, if the oxides are dissolved in quenching the dip is partially refined, if the oxides are not dissolved the dip is debased. Also a little slag adhering to the dip will vitiate the assay if not carefully removed from the assay piece.

Clip or Chip Samples.—These can only be taken from bullion which is homogeneous, if any liquation has taken place they are unreliable. A good method of taking this class of sample is to clean the outer surface of the bar where the sample is to be taken with a file or scratch brush, and take the sample over a moderate depth and large area.

Drill Samples.—These are similar to "clip" samples, but are more difficult to take, particularly when large numbers of samples have to be taken. Unless great care is exercised they are liable to contamination. Drill samples are conveniently used for sampling a bar which is suspected of being non-homogeneous, and which it is not convenient to melt. A sufficient number of samples can be made to give a fairly accurate result on such a bar.

To summarise it may be stated that no one method of sampling gold bullion is applicable to all classes of bullion produced by the various mines. Generally, a dip sample gives a slightly high result, and a clip sample a slightly low result; drill samples are not used to any extent where large numbers of samples of all classes of bullion are taken. The word "slightly" has been used above because it is only by examining a large number of results that the difference can be noticed. With fine gold it is a different matter as it makes no practical difference if a dip, clip or drill sample is taken provided all precautions are taken with each kind of sample.

Reference was made to the refinery which is being established, and, therefore, a brief account of the methods to be used will probably be of interest to the members of this Society.

In order to illustrate the points under discussion, let us consider what is likely to happen to a bar of bullion.

The bar will be melted with suitable fluxes, and when at the correct temperature will be thoroughly mixed with a specially shaped plumbago stirrer which has the effect of lifting the molten metal from the bottom of the crucible, not simply setting up a circular motion in the molten metal. Dip samples will then be taken with a dipping iron so constructed that the samples will be taken simultaneously from different depths of the molten metal. The dips will be quenched in water and the bullion after pouring into ingots of 300-350 ozs. weights, will be quenched in water slightly acidified with sulphuric acid.

The bars after cleaning will be sampled in the presence of two persons by taking clip samples from different ingots. Half the number of clip samples and half the number of the dip samples will be sent to one assayer and the remainder of the samples will be sent to another assayer. Each assayer will obtain his results by using different furnaces, different apparatus and even different methods of weighing and different proof gold for obtaining the surcharge corrections. In fact, the assay reports will be obtained in different assay offices using methods as different as is possible in bullion assaying. Then if, when the reports by each assayer are finally brought together, it is found that the clip assays agree within limits, and the dip assays agree within limits, and finally if the mean of the clip reports and the mean of the dip reports agree within certain limits, the mean of the clip and dip reports is taken as the fineness of the bar.

If for any reason the assay report on any sample is suspected of being inaccurate, a repeat assay is made on the same sample, and if the inaccuracy of the original report is confirmed, the new result is substituted before obtaining the final result.

When the various assay reports considered as above do not agree, the bar is subjected to further treatment which may consist of remelting the bars obtained or subjecting them to a preliminary refining. Generally, when concordant assay results are not obtained the cause is due to the presence of an excess of base metals which must be removed before concordant assay results can be obtained; this is done by a preliminary refining.

It is important to notice that the refinery will not trust to dip samples alone. The dip samples become separated from the bars before final despatch to the assayers, and hence there are possibilities of transpositions. Therefore, clip samples are always sent in conjunction with dip samples to make an error of this nature easily detected

The writer has been concerned with the melting, sampling and assaying of several hundred thousand bars of bullion. Mistakes have occurred in some of the operations, but with the system used these have been quickly detected, and in all cases the final official return to the producer has been of unquestioned accuracy.

The above remarks about the refinery methods have necessarily been very brief: in fact, so brief that mention has not even been made of all the precautions taken to ensure great accuracy and to avoid all kinds of mistakes. Such details of the methods of checking weights, adjustment of assay balance, special methods for assaying the proof gold used for checks, etc., could each be the subject for a contribution to the Society.

The writer agrees with Mr. Wilkes' suggestion that with the establishment of the Rand refinery an effort should be made to standardise methods in all the assay offices along the Reef. It may be taken for granted that the refinery staff will at all times be prepared to discuss standard methods. In this connection it may interest members of this Society to know that a portion of the equipment of the refinery consists of sets of troy weights and assay weights standardised by the National Physical Laboratory, so that in due course it should be possible to arrange for the periodical checking of weights. Also the refinery will have a fine gold trial plate certified by the Board of Trade, England. This will be used for assaying fine gold used to obtain surcharge differences, and no doubt some of the assay offices along the Reef will be able to obtain fine gold for the bullion assay which has been standardised against the Board of Trade standard.

In the course of discussion mention was made of platinum parting apparatus. The refinery will use platinum parting trays to part 72 assays at one time. With platinum at £26 per ounce such a tray, without the cups, cost £257; a full set of 72 platinum cups for such a tray costs another £221. A very satisfactory arrangement is to have a platinum tray and silica cups. The silica cups cost about 3/- each against (say) £3 each for platinum cups, and are probably better for working, the gold cornets never adhering to the silica as they sometimes do to the platinum.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Carbon Black: Its Properties and Uses.—"Most of the carbon black now manufactured in the United States is made by the "channel" system, in which the black from natural gas is deposited upon the smooth under-surface of steel channels by means of burners 3 in. to 4 in. below them. The channels are arranged in tables of eight, and are given a slow reciprocating motion whereby the deposited black is scraped from them into hoppers. The quality of the product varies with the amount of air, the speed of scraping, and the pressure of the gas. In accordance with the conclusions of Bone and his co-workers, gases rich in ethane and higher homologues give greater yields of carbon by this method. The temperature

of the channels is maintained at about 300° C. At the present time only relatively small quantities of lampblack are used for printers' ink, and then only in admixture with carbon black. Carbon black is used in rubber mixings and in the paint trade; its sp. gr. is 1·8 and it has a greater tinting and covering capacity than any other black. *Testing Methods:* The tinting strength and colour are estimated by comparison with a standard black, the former with a mixture of the black and zinc oxide and the latter with the black itself, in both cases mixed with oil. Chemical tests include those for moisture, ash, and acetone extract. An acetone extract exceeding 0·1% indicates adulteration with a poorly calcined lampblack. A sample containing more than 0·2% ash is probably adulterated with mineral black or charcoal. Most blacks for ink contain 2—4% moisture, though certain kinds may contain up to 7%. Some blacks will absorb as much as 15% of their weight of moisture. Specifications are suggested for printing ink, rubber, and paint. The use of the torsion viscosimeter will indicate the behaviour of a black in practice. When equal weight of blacks with the same amount of raw linseed oil are tested by means of MacMichael's apparatus, the lowest readings are given by those kinds valued by ink makers for their "length." *Chemical analysis:* Carbon blacks contain 85% to 95% amorphous carbon, 1% to 7% water, 0·5% to 0·8% hydrogen, and 2% to 8% oxygen (partly as CO and CO_2, partly as fixed oxygen). A black yielding a "long" ink is usually low in carbon and high in volatile matter and oxygen, whilst "shorter" blacks show the reverse. Typical analyses are given. As a rule, "long" blacks are more hygroscopic than "short" blacks. They may also be distinguished microscopically in freshly-prepared mixtures with their lithographic varnish, "short" blacks gradually agglomerating into groups of 20 to 100 particles, whereas the particles of "long" blacks remain completely dispersed after several hours."—G. St. J. Perrott and R. Thiessen, *J. Ind. Eng. Chem.*, 1920, *12*, 324-331.—*Jour. Soc. Chem. Ind.*, 31st May, 1920, p. 377A (J. A. W.)

Indicators and Their Industrial Application. —"In the precipitation of anthranilic acid from its alkaline solution by the addition of mineral acid, an acid reaction to methyl-red indicates that the end-point is approached; on further addition of acid the point of maximum precipitation is shown by an acid reaction to thymol-blue. Thymolsulphophthalein is a useful indicator in the "liming" of sulphonation mixtures; a red coloration indicates that free acid is still present. When the indicator shows a yellow colour the end-point is near, whilst a blue colour shows that the mixture is alkaline. Dibromocresolsulphophthalein or dibromothymolsulphophthalein may be used as substitutes for litmus; the former changes from yellow to purple and the latter from yellow to blue."—H. A. Lubs, *J. Ind. Eng. Chem.*, 1920, *12*, 273-274.—*Jour. Soc. Chem. Ind.*, 15th June, 1920, p. 430A. (J. A. W.)

The Formaldehyde Method of Titrating Ammonium Nitrate.—"Neutral 20% formaldehyde solution is added to the ammonium nitrate solution, the mixture heated to 60° C., and titrated with $N/3$ sodium hydroxide solution, using phenolphthalein as indicator. The reaction proceeds according to the equation: $6CH_2O + 4NH_4NO_3 + 4NaOH = C_6H_{12}N_4 + 4NaNO_3 + 10H_2O$. The results are consistently about 0·25% too low.—J. T. Grissom, *J. Ind. Eng. Chem*, 1920, *12*, 172-173.—*Jour. Soc. Chem. Ind.*, 15th May, 1920, p. 332A. (J. A. W.)

METALLURGY.

Recent Developments of the Electric Furnace. —"In no branch of metallurgy have greater advances been made during the war than in the development and use of alloys, such as those of nickel, chromium, molybdenum, or manganese, and the electric furnace has been responsible in most cases for both the reduction of these refractory metals from their ores and the subsequent manufacture of the alloy steels for these special purposes. Newcastle has been the principal centre for the reduction of chromium, tungsten, and molybdenum ores, and at the time of the Armistice works were in regular operation of sufficient capacity to produce Britain's war requirements of these essential metals.

In 1914 the quantity of energy used on electric furnaces in Britain, excluding those used for aluminium, was probably less than 6,000 h.p., but on the day of the Armistice the total capacity was in excess of 150,000 h.p., of which 135,000 h.p. was producing steel, and 18,000 h.p. was working on the reduction of chromium and tungsten ores. On the day of the Armistice electric energy was being consumed at the rate of nearly 3,000,000 kw.-hrs. per annum for this purpose alone. The electric steel production had then reached a total of over 200,000 tons per annum

The tendency in electric-furnace design is rather to increase the power of transformers on furnaces of moderate capacity than to build large furnaces One limiting factor is the size of electrodes that can be conveniently employed, but if there be any demand for larger furnaces, there is no objection to the use of six or more electrodes. If large tonnages of electrically-refined steel are wanted, it is customary to refine steel previously melted and treated by the Bessemer or Thomas process, and in that case the electric furnace need never be of more than 25 tons capacity, which is the largest vessel used for these processes.

There are technical disadvantages in electric furnaces of more than 25 tons or more than 3,000 kw. capacity, and there is no advantage in using the furnaces of 6,000-7,000 kw. which have been recommended abroad for making alloys and carbide. In most furnaces of the arc type, regulation of load is effected by variation of the arc gap, either by hand or automatic regulation. The latter system has probably been more highly developed in this than in any other country, owing to the high cost of power, and the system by which individual furnaces are kept at any desired contant load by Thury automatic regulators is widely applied. The regulation also materially assists in keeping both the composition of the bath and temperature of the furnace within desired limits. In addition, the regulation of a battery of furnaces by a master instrument is of especial interest to power producers and those who pay for energy on a maximum-demand basis. An instrument is finding application which will keep the total load of a battery of furnaces within desired limits by slightly reducing the load on the furnaces if the demand at any time exceeds the total load which the station engineer or the power contract may set as maximum total load to be utilised. Individual furnaces can be removed from the influence of the master

regulator by drawing a switch, but the energy absorbed by that furnace is always included in the total power which the regulator will allow the furnaces to absorb.

There are great advantages in establishing certain electro-metallurgical processes in England, in spite of the lack of water power, for this country is so highly favoured with the other essentials for successful industry that the supposed advantages of cheap hydro-electric energy are counterbalanced in the case of many processes in which skill and cheap raw materials are important factors; consequently power economically generated from steam and efficiently distributed may form the basis of many electro-chemical industries.

The production of aluminium, ferro-silicon, and carbide are industries for which water power is usually essential, but in steel-making the quantity of energy used is comparatively small, and the skill and special plant required for its treatment are so great, that the local advantages of England outweigh the advantages of low-power cost abroad. Processes such as steel-making that only use about 40 per cent. load factor, *i.e.*, four-tenths of the possible output of the plant reserved for their use, are more suitable for steam stations which have low capital expenditure and high running costs, rather than hydro-electric stations, which involve the outlay of large sums for capital account, but small operating expenses.

The next immediate development will probably be the general application of electric smelting to the treatment of complex zinc ores and the gradual improvement of existing processes in the development of power and utilisation of the fuel we now waste. Further, the phenomenal growth in the world's consumption of aluminium and the great possibilities of its alloys offer a fruitful field for investigation and industrial enterprise.

Electro-metallurgy is still in its infancy, but its growth is rapid. Abroad, generating stations of 100,000 h.p. are being used exclusively in single industries, and electro-metallurgical centres, absorbing several hundred thousand h.p., are being developed in various countries, while many similar projects are under consideration."—D. F. Campbell, *Iron and Coal Trades' Review*, July 16, 1920, p. 77. (J. A. W.)

Nickel Plating Aluminium.—According to a note presented to the Academie des Sciences, published in *La Technique Moderne*, Messrs. Leon Guillet and Maxime Gasnier have solved the difficult problem of depositing nickel on aluminium. The surface of the metal is first sand-blasted, with sand that is passed through a sieve with 0·2 mm. meshes, under an air pressure of 1500 gm. per cm². A deposit of nickel 0·006 mm thick is then made, with a current of 0·8 ampere per dm² for half an hour, after which a coating of copper is applied, 0·02 mm thick, the operation lasting two hours with a current of 1 ampere per dm². The copper is then polished, plated with nickel 0·005 mm. thick (0·5 ampere per dm² for one hour) and the nickel is polished. This process gives a smooth adherent coating, passing mechanical and chemical tests, and not only ensures the durable protection of the aluminium, but also enables it to be soldered by the ordinary processes. The nickel bath consists of sulphate of nickel, 150 gm., double sulphate of nickel and ammonia 50 gm., water to 1 litre; the copper bath of copper sulphate 150 gm., sulphuric acid 20 gm., water to 1 litre.—*Indian Engineering*, Nov. 13, 1920, p. 275. (J. A. W.)

Acetylene Welding of Aluminium.—The chemical factory at Frankfort on Maine has introduced a new process which entirely prevents the formation of oxides of aluminium, and produces a weld which is of the same strength as the metal itself, and can be rolled and hammered. The method is applicable to castings, sheet metal, etc., and depends chiefly on the admixture of a small quantity of fluorine to the ordinary flux made with 60 parts of chloride of potash, 12 parts of chloride of soda, and 4 parts of sulphate of potash. This flux, which may be used as a powder mixed with water to a paste, melts under the acetylene flame sooner than the aluminium and fully protects the heated surfaces from the air. A perfectly homogenous joint is obtained with the greatest ease, and without risk of impurities entering. The flux can also be used in crucibles for melting scrap aluminium, as it effectually prevents any loss of metal by oxidation—Anon.—*Ind. Eng.*, 2nd October, 1920, p. 187. (J. A. W.)

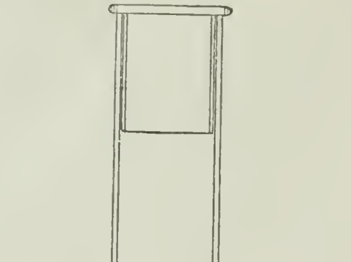
Bullion Assaying.—"In making bullion assays considerable trouble is often encountered from bumping in the flask, even when means are taken to prevent it. The standard platinum cups and tray are not a solution of all difficulties, for gold cornets can break up in platinum cups as well as stick to them, if not manipulated with the utmost care. I have found from experience that the boiling and parting, as well as the washing of the cornet, can best be carried on in a high-form porcelain crucible or cup, glazed inside and outside. The crucible should be at least 1⅝in. in diameter across the top, 1⅜ to 1½in. high and of at least 30 cc. capacity. The upward outward sloping sides allow the bubbles free egression, thus preventing any serious bumping or upsetting. With the flask the top is the narrowest part; the gases and bubbles on ascending are compressed, strike the sides, and bumping sets in no matter how many burnt peas or lentils are used."—R. Wheeler, *Eng. and Min. Journal*, July 24, 1920, p. 158. (H. A. W.)

MINING.

Field Microscope for Mining Engineers.—"According to a paper presented by Dr. W. Myron Davy, of Cambridge, Mass., to the American Institute of Mining and Metallurgy, the simplest microscope obtainable is intended for laboratory use and is much too bulky for the average field equipment. Methods previously described for polishing specimens have necessitated electrically driven lap wheels, which are found only in permanent installations. Hence it is small wonder that the subject has been looked upon as being too involved for the field.

To overcome these difficulties Dr. Davy has designed an outfit that has proved highly useful. It consists of a microscope of the simplest construction and weighing only 8oz. complete. The magnification obtainable is about 75 diameters, which has been found to be well suited to average work of all kinds; but this can be varied within wide limits by changes in the ocular and objective,

which are of the general type common in most metallographic microscopes. The optical principle involved and the arrangement in use are shown in the accompanying illustration.



The materials for hand polishing include a coarse carborundum grinding stone, a square plate of glass, linen, a chamois-covered block, and tins of polishing powders. The entire outfit is compactly packed into a small case. To prepare a specimen for examination, a surface 2 to 1in. square is chipped flat with a hammer and then ground to a plane surface upon the cutting stone. All grinding and polishing, except on leather, is done wet, care being taken that the specimen does not become heated because the sulphides undergo alteration under the heat of excessive friction. All rubbing is done in a circular path to prevent parallel scratching and grooving of both the specimen and the polishing surface. After careful washing, the specimen is ground upon the plate glass, using a thin paste of optical alundum and water.

For examination, the polished specimen is pushed into the lump of modelling clay in the levelling tube. The tube, with its base, clay, and specimen, is inverted and pushed firmly down on any level surface, thus bringing the polished section flush with the top of the surrounding tube.

The reagents used in identifying the minerals on a polished surface are :—(1) HNO_3, one part concentrated acid (sp. gr. = 1.42) and one part water; (2) HCl, one part concentrated acid (sp. gr. = 1.19) and one part water; (3) KCN, 20 per cent. solution in water; (4) $FeCl_3$, 20 per cent. solution in water; (5) $HgCl_2$, saturated solution in water; (6) KOH, saturated solution in water. These reagents are conveniently applied to the polished surface by the use of a pipette with a fine capillary opening and fitted with a small rubber bulb."—W. M. Davy, *I. and C.T. Review*, Sept. 3, 1920, p. 203. (J. A. W.)

Indicators for Carbon Dioxide and Oxygen.—The U.S. Bureau of Mines has evolved three types of portable indicators in its chemical research laboratory at the Pittsburgh Station. One determines the CO_2 content in the air, one determines it in flue gases, and the third determines the oxygen content of the air. The indicators are of great value to persons who have to work in confined situations, or in the presence of flue gases. Increase of CO_2 and decrease of oxygen content in air always occur together as when there is a fire, or numbers of men breathe in a confined space, or when surface oxidation of coal takes place in a coal mine. When a man breathes air containing more than 2% of CO_2 his working efficiency is reduced; and he is in real danger when the air he breathes contains more than 4% of CO_2 or less than 13% of oxygen. The efficiency of all fuels is greatest when oxidation is complete and this condition holds when the flue gases have a high CO_2 content. It is important therefore to make frequent determination of CO_2 in flue gases, hence the value of a simple and portable instrument for the purpose.—*Indian Eng.*, Nov. 20, 1920, p. 286. (J. A. W.)

MISCELLANEOUS.

Value of Coal Dust.—The principal seat of the South Wales coal briquetting or patent fuel trade is Swansea, where there are nine works at present in operation, including the largest single fuel works in the world. Important works are to be found also at Cardiff, Port Talbot and Newport, and smaller ones at other places. There are in all 17 such works now operating in South Wales; three additional large works are in process of erection, and several others are projected. The total output at the existing works is approximately 13,000 tons per day.

The magnitude of the industry which has gradually grown up from very small beginnings is demonstrated by the present output figure already mentioned, while its importance as an auxiliary to the South Wales coal trade cannot easily be overestimated. It is true that while the patent fuel trade has been growing up, new and improved methods for the utilisation of small coal in boiler-firing have been continually introduced, and in the case of those qualities best adapted to the purpose the quantity used in foundry-coke and by-product installations is very greatly increased; but nevertheless it is probably not an exaggeration to say that if the fuel works were to cease operations a great many South Wales collieries would find it impossible to continue working, because they would have no outlet for their small coal, and present day conditions would make it quite impossible for them to revert to the pre-fuel system of regarding the small coal as waste to be paid for out of the profit on the large.

Main Processes.—There are several methods in use for the manufacture of patent fuel, and innumerable patents have been taken out for processes of varying merit during the past half-cen-

tury, but, broadly speaking, all the systems in current use in South Wales are variants of one method, involving the use of several successive processes, and representing the experience of 50 years of investigation.

It would be out of place to mention here the points of difference between the different methods, or their advantages and disadvantages, or to enter into any technical description of the processes or the machinery used in carrying them out. It will be sufficient to explain in general terms the five principal stages of manufacture.

First, the small coal as received from the colliery is washed to free it from stone, slag, and other extraneous matter, and during this process it is also separated into different sizes, the largest of which command a ready sale at good prices as washed nuts and washed beans. In this connection it should be borne in mind that all the coals used in fuel manufacture are of first-class quality, and, therefore, the washed nuts and beans, freed as they are from all foreign matter, form a very superior article for use wherever a really high-grade coal is required. The fine dust, or duff, which remains after the stones and sized coals are extracted is then dried and delivered into the factory bins.

The second stage is the mixing of the coal with the agglutinant or binder. Scores of different binders, of all sorts and descriptions, have been tested at different times with varying success, but the experience of half a century has shown that the best binder obtainable up to the present is coal-tar pitch, and this is the article which is now universally employed for the purpose, although some manufacturers employ a small proportion of other materials in addition to pitch. The pitch is crushed to a suitable size and mixed with the coal in the proportions of about eight parts of the former to 92 of the latter.

The third stage is the grinding of the mixture of coal and pitch to a small and uniform size, and during this process of grinding the mixing of the particles of the different materials becomes very intimate. This is a point of great importance, since it is essential that when the pitch is subsequently liquefied by the application of heat, every particle of coal, however minute, should be entirely covered by a thin film of pitch. Failure to attain this object would mean that the finished article would lack the solidity and homogeneity which are notable features of South Wales patent fuel.

The next step is the heating of the mixture by means of superheated steam, and the final process is the pressing of the warm, "sticky" mixture into hard, dense, well-finished blocks, usually of workmanlike and pleasing appearance. By far the greater portion of the South Wales output is turned out in the form of rectangular blocks of varying dimensions, weighing from 9lb. to 28lb. each; but of late years some makers have turned their attention to the production of ovoids or boulets—small egg-shaped blocks.

It will be seen that from the time of the arrival at the factory of the coal and pitch until the delivery from the press of the finished article, the whole of the treatment is effected by machinery, and it may be remarked in passing that the plant used in a modern fuel works is of a heavy and powerful type, and much of it is of a most ingenious and interesting description. The subsequent operations necessary to the disposal of the fuel in truck or on board ship present difficulties which up to the present it has been found impossible to deal with by mechanical means. The fuel, therefore, is removed from the presses and stowed on trolleys by manual labour; the trolleys are allowed to stand under load for a length of time sufficient to permit of the cooling of the fuel and the evaporation of the moisture resulting from the injection of steam, and they are then slung on board ship by means of electric or hydraulic cranes, and the fuel is removed by hand and carefully stowed.

The fuel produced in South Wales possesses advantages over the best Welsh coal, which is admittedly the finest in the world

Amongst these advantages may be mentioned:—(1) The proportion of small produced in shipment, transportation and discharging is only about 5%, as against 25 to 30 per cent. in the case of large coal. (2) Patent fuel occupies less space than coal, a ton occupying only about 34 cubic feet, as against 45 cubic feet in the case of large coal. (3) Owing to its regular shape it can be readily stored in the open in any quantity without the necessity of retaining walls. (4) It is impervious to rain, snow, or frost, and quite unaffected by extremes of heat, and may, therefore, be stored for an unlimited length of time, in the open air, in any climate, without suffering any deterioration. (5) It is quite free from all danger of spontaneous combustion.

Foreign Markets.—In addition to these advantages, patent fuel possesses all the good qualities which have made Welsh coals famous all over the world—high steam-raising efficiency, freedom from smoke, low percentage of ash, and the quality of opening out well and forming a strong coke without loss through decrepitation.

The principal importing markets are France, Italy, Algeria and Tunisia, but all the other countries having ports on the Mediterranean, West Africa and South America are regular buyers, taking large and constantly increasing quantities.

Patent fuel finds its chief employment for railway purposes, for which it is the combustible *par excellence*, but it is also used with most satisfactory results in steam navigation and for stationary engines, steam tractors, and steam-driven agricultural machinery, and for industrial and domestic purposes.

Within the past two or three years great changes have taken place in the ownership of practically every works in South Wales, and almost without exception they are now owned by, or closely identified with, one or other of the leading colliery enterprises—a development which is significant testimony to the importance of the trade and the prospects of its future expansion.—*The Times Trade Supplement*, 18th December, 1920. (W. A. C.)

Abstract of Patent Applications.

963.19. The Central Mining and Investment Corporation, Ltd., and Walter Wolstenholme. Improvements in reinforcing cement and like pipes. 26.11.19.

This application refers to pipes, columns and the like made of cement and other hardening plastic material, and proposes to substitute for the usual reinforcement of woven wire, a cylinder of sheet metal which may or may not be perforated, embedded within the thickness of the pipe. The proposed method of manufacture by the centrifugal process is described.

1022.19. S. Fisher. Improvements in mounting for hammer drills. 13.12.19.

This application refers to mountings for rock

drills of the hammer type, in which the hammer or piston strikes the drill tool, which is held in the chuck of the machine by what is necessarily a somewhat loose connection, the purpose being to provide a self-aligning drill support in which tendency to lateral wander due to sagging of the drill is eliminated or materially reduced, and in which such lateral wander as still occurs is met by a corresponding movement of the whole structure.

According to this application a rig or support for a rock drill of the hammer type consists of a carriage (supporting the drilling machine) which slides on a T iron guide or cradle. The latter is supported at its rear end on an anchor or on a bar, and the forward end is suspended from the drill tool in the hole being drilled by a part called the "bridge," which is provided with a renewable wearing piece. A toggle point for temporarily resting the front end of the rig on the face during collaring is also described.

35.20. J. H. Stuthridge. Improvements in or relating to tube mill liners. 13.1.20.

This application relates to improvements in tube mill linings of the type consisting of curved plates carrying projections to form radial bars, etc.—generally known as the "El Oro" types. The improvement consists in providing lugs and recesses in such plates or units which, when placed in position serve to interlock such units and facilitate the relining of the mill.

580.20. E. W. Robey. Improvements relating to conveyors. 14.6.20.

This application refers to a combination with a hopper or the like from which material is discharged into a trough which contains water sealing the discharge opening and a conveyor removing the material, to conveyors in the same trough, or each in a separate trough and a device whereby the material may be discharged to either conveyor while the other remains out of use.

1043.20. W. R. Hume. An improved method of and means for moulding cement and concrete bodies. 17.9.20.

This application refers to an improved method of and means for moulding cement and concrete bodies, and more particularly refers to the manufacture of pipes which are oviform, oval or other non-circular shape in section. But it is also applicable to the moulding of other structural bodies.

According to this application moulds of the desired shape are mounted upon a circular table which revolves in a horizontal plane. The table is carried on wheels or rollers at the periphery which run upon rails forming a circular track.

If plain wheels are used to carry the table, the rails are serrated or corrugated, alternatively if the rails are plain, the wheels are formed with undulations or irregularities on their periphery, the object being to produce a "jarring" or "bumping," or a series of vertical vibrations, the effect of which is to closely pack or consolidate the concrete in the moulds.

Means for driving the table are described, also a method of supplying concrete to moulds at different points on the table by chutes from a central elevated hopper. Any known means for varying the rotational speed of the table may be used.

1075.20. Cobb Electric Reduction Corporation of Canada. Improvements in and relating to the method of and apparatus for the reduction of ores. 29.9.20.

This is an application for a process and apparatus claim, and applies to the melting of metallic ores by heat of direct current electrically.

The application covers many different ways of carrying out the process, and specifically describes the apparatus applying thereto.

1089.20. J. R. Broadley. Improvements in or relating to machines for grinding ores, minerals, stones and the like. 6.10.20.

The object of this application is to provide an improved construction of machine which combines the functions of a tube mill with those of a hydraulic classifier for the purpose of passing out the ore when it is ground sufficiently fine and retaining the oversize.

The design of the machine provides for a tube mill divided into two compartments by means of a perforated diaphragm plate. In the first compartment grinding is carried on as in usual practice. The second compartment, by means of vanes and baffles, functions as a separator of the sufficiently ground ore from the oversize; the former passing out through the end trunnion of the tube and the latter being retained to the grinding compartment for further grinding by means of a spiral in a tube or a scoop.

1091.20. R. D. George. Process and apparatus for decomposing heavy hydrocarbon oils into lighter oils. 6.10.20.

This application refers more especially to the production of motor fuel from heavy oils, the main feature being the treatment of the oil under pressure in a closed circuit with provision for the removal of the free carbon.

The oil to be treated is pumped under pressure (about 90 lb.) through a coil which is contained in a chamber which receives the hot light oils from the distillation. The oil then passes through a carbon extractor in the shape of a vertical cylinder divided into two compartments by a fine mesh screen. The heavier oil and carbon settled out of the distilled product enters this chamber below the screen, which prevents the carbon going back to the still, and the fresh oil to be treated is delivered above the screen. The two mix and flow from an opening above the screen to a vertical still which is provided with a mechanical scraper for removing the carbon from the sides of the still. The light oil vapours of the distillation passing to the chamber first mentioned, heat the coil containing the incoming oil, and subsequently, after allowing the heavier portion of the fractionalised oil to settle, the lighter oil passes through a condenser coil and thence to the storage tank.

Changes of Address.

Blandford, T., *l/o* Johannesburg: 13, Town Moor Avenue, Doncaster.

Bell, H. C. F., *l/o* Benoni: Pilgrims Rest.

Thorne, T. L., *l/o* Cleveland: 126, Seventh Street, Springs.

Watermeyer, Professor G. A., *l/o* Gen. Mining and Finance Corpn., Ltd.: University College, P.O. Box 1176, Johannesburg.

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Proceedings

AT

Ordinary General Meeting,

16th April, 1921.

The Ordinary General Meeting of the Society was held in the Assembly Hall, Scientific and Technical Club, 100, Fox Street, Johannesburg, on Saturday, the 16th April, 1921, at 8 p.m., Mr. F. Wartenweiler (Vice-President) in the Chair. There were also present:—

22 Members: Prof. G. A. Watermeyer, Messrs. F. W. Watson, C. J. Gray, J. Hayward Johnson, Andrew King, Dr. A. J. Orenstein, J. J. R. Smythe, E. M. Weston, A. Whitby, H. A. White, J. A. Woodburn, E. H. Johnson, Dr. J. Moir, J. E. Thomas (Members of Council), William Allen, E. L. Hawes, K. Leinberger, H. W. Pridgeon, L. G. Ray, W. E. Thorpe, C. Toombs and H. R. S. Wilkes.

5 Associates: H. C. F. Bell, J. A. Boyd, O. A. Gerber, F. J. Kisbey-Green and H. Rusden.

10 Visitors and H. A. G. Jeffreys (Secretary).

The Chairman: I have to announce that our President, Mr. Chilton, has left for a visit to England rather unexpectedly, and he has left the business of the Society in the hands of its officials, and it therefore devolves on me to act as Chairman to-night. It is proposed that the other Vice-Presidents will preside at the succeeding meetings in May and June.

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 19th March, 1921, as recorded in the March *Journal*, were confirmed.

NEW MEMBERS

A ballot was taken for the election of new members, and the following were declared unanimously elected:—

Brock, Hugo Tabor, P.O., Northrand: Travelling Instructor, B.S.A. Explosives Co. Ltd.
Hedley, Edgar Percy, 24, Timber Street, Maritzburg. Chemist.
Homersham, Edwin Collett, Minerals Separation, Ltd., P.O. Box 2959, Johannesburg: Mining Engineer.
Levieux, Jean, P.O. Box 3911, Johannesburg: Mining Engineer.
Lindemann, William Charles, 213, St. Amant Street, Malvern, Johannesburg: Engineer.
Simpson, Tudor Rees, Minerals Separation, Ltd., P.O. 2959, Johannesburg: Chemist and Metallurgist.

GENERAL BUSINESS.

A RICH NICKEL ORE.

Mr. Andrew F. Crosse: Mr. Jas. Gray has written a criticism on my analysis of a nickel ore found near Barberton. I do not think that Mr. Gray's style of criticism is called for, and I am of opinion that this class of criticism is by no means advantageous to our Society, and has probably had the effect of preventing members contributing papers, as many of us object to having our technical and scientific opinions treated in this way.

It must not be forgotten that this mineral as far as I have been able to find out is undescribed in any work on mineralogy.

There is another "known" oxide of nickel, viz., Ni_3O_4 or $NiO.Ni_3O_2$ (see Dana's Mineralogy), and to this the nickel present was calculated giving 10·3%. The figure for oxide of nickel need not be taken as exact; but this would be of only scientific interest, the equivalent percentage of metallic nickel being the figure of commercial value.

No magnesia was present in the sample. Garnierite was absent, and all the nickel

present was presumed to be oxide, as no sulphur or arsenic was found. I would like to emphasise that this remark applies to this particular sample, as garnierite is certainly present in the poorer classes of the ore.

Copper, zinc, chromium and titanium were absent.

The circumstance of Mr. Gray's figure (of a year ago) for nickel contents and mine being so close, I regard merely as a coincidence as a deposit like this varies immensely in composition.

METHODS USED IN THE DETECTION AND INVESTIGATION OF VITAMINES.

By E. Marion Delf, B.A., D.Sc. (Lond.), F.L.S.

Dr. E. Marion Delf: Ladies and gentlemen, I must apologise for the title of this paper, which is not perhaps a very exact one. In the first place, I propose to deal partly with methods and partly with results; and, in the second place, it is a very large subject—almost too large a subject to deal with in the compass of one rather short lecture. But I chose the subject, because, at the present time, the literature dealing with vitamines is very considerable; there is a great deal of material, and, in studying it, one becomes impressed with the cumulative results of different lines of research. Experiments started from different points of view all converge, and give one more and more idea of the fundamental importance of these so-called vitamines.

INTRODUCTION.

The concept of vitamins as necessary elements in the food of animals is one which has come to stay. The chemical nature of these substances, however, is still unknown, and much of the recent work reveals their properties rather than chemical identity, as is also the case, indeed, with such comparatively familiar substances as toxins, antitoxins, and enzymes. According to a recent writer of high repute[1] in this class of work, a vitamine is a neutral substance of unknown composition, and can be physiologically characterised as (a) indispensable to animals; and (b) as having a low effective concentration (the nutritional influence being altogether out of propo tion to the concentration needed in the food). To this we might add that many observers believe that vitamines are manufactured by the plant in the course of its normal metabolic processes, whilst, according to others,[1] the plant itself may absorb these or related substances arising from bacterial action in the soil.

Three vitamines are now well recognised, and they have been variously styled as vitamines, nutramines, accessory food factors or, more recently, vitamins. Following the suggestion of Drummond[2] I shall distinguish these as Vitamin A, B and C respectively. Vitamin A is the so-called fat-soluble accessory factor of McCollum and Davis: it is characteristic of green food and the yellower animal fats. Vitamin B has long been known as water soluble B, and is characteristic of seeds of plants and of the fungus, yeast. Vitamin C is probably better known as the antiscorbutic accessory factor, and is present in greater or less amount in fresh fruits and vegetables. In the case of prolonged total absence of any of these elements in the diet, an animal will surely die, but in partial absence, or in temporary complete absence, disease may supervene specific to the particular missing element. Thus in man scurvy surely follows a withdrawal of the antiscorbutic elements in the diet; beriberi follows from lack of B; and rickets (in infants) or various types of osteomalacia (in adults) are associated with a lack of A. Amongst animals, all are not equally susceptible to these deficiencies, although there is no reason to suppose that any animal could withstand total deprivation of any of these vitamins for an indefinite period; thus growing rats are very susceptible to a growth check from lack of A; young dogs and kittens to rickets in similar deprivation of A, and pigeons and birds lacking B easily succumb to polyneuritis which appears to represent an avian beriberi very completely; whilst guinea-pigs are very susceptible to scurvy, in default of C.

RESEARCH METHODS.

The labours of many workers in England, America, and in Vienna have added much to our knowledge of these three vitamins. We know something of their distribution in

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[1] Prof. Gowland Hopkins, *Lancet*, 1st January, 1921.

[1] Prof. Bottomley, *Ann. Bot.*, 1920, 34, p. 353.

[2] Drummond, J. C., *Biochem. Journal*, December, 1920.

natural food products: of their destruction or survival under certain manufacturing processes; and of their importances in the general welfare of the body, as well as in the specific diseases mentioned. This work has been undertaken from various points of view, but consideration of the literature shows three principal lines of research:—

(a) The biochemical.

(b) The biological, involving (1) the use of experimental animals; (2) the use of experimental plants; (3) observations on human beings.

(c) The physiological.

It is my purpose to describe some of the methods which have been used in these three directions, with especial reference to those of (b) with which I am personally acquainted.

(a) *Biochemical Methods.*—Many attempts have been made to isolate a vitamin, and to determine its chemical composition. Vitamin B is the most satisfactory for this purpose, being by far the most stable of the three known vitamins. The pioneer in this work was Funk, who, in 1913, published an account of his experiments with an alcoholic extract of rice polishings. By precipitating with phosphotungstic acid and subsequent fractionation of the substances precipitated by silver nitrate and baryta water he obtained a crystalline substance belonging to the class of pyramidin bases. This substance had a curative effect on pigeons suffering from polyneuritis which was very similar to the curative effect of the original rice polishings.

Subsequent workers have claimed to find active substances such as oryzanin in the form of an alkaline picrate (Susuki and others); the torulin of Edie, Evans and others obtained from yeast; and the adenin from yeast of Williams and Seidell.[1] More recently Myers and Voegtlin[2] claim that the antineuritic, or B vitamin, can be extracted from dried yeast with methyl alcohol, purified by the Funk method, and found as a crystallisable substance of the nature of a histamin.

The criticism which seems to be applicable to all these claims is that put forward by Barger, and again by Drummond and Funk, that these preparations are simply nitrogenous bases with adhering traces of the elusive vitamin B. On keeping, the activity of these traces also disappears. The isolation of the unstable A and C factors has not as yet been claimed. (Harden and Zilva found B was adsorbed when filtered through fuller's earth, whereas C was not. However, A and C are usually associated together in nature (as in green leaves), and these have not yet been separated.

From the biochemical point of view, therefore, we must admit that the chemical nature of the vitamins remains unknown. On the other hand, important advances have been made in our knowledge of the properties of A, B and C, by these means. I may instance here the work of Harden and Zilva[1] on the susceptibility of the antiscorbutic principle to the influence of alkalis, and a contribution which promises to be of still greater importance is the recent work of Zilva on aeration and the antiscorbutic factor.[2] In this Zilva claims to have shown that lemon juice can be boiled in an atmosphere of CO_2 for two hours without any visible deterioration in its efficiency, whilst, when air was aspirated through lemon juice for 12 hours at ordinary temperatures, a nearly complete loss of activity occurred. It has long been suspected that the presence of oxygen was a factor also in the behaviour of the fat-soluble substance (Vitamin A) towards heat, and if these results are confirmed,[3] they will probably explain some of the conflicting evidence of the past, as well as throw light on possible improvements in the way of producing stable commercial products possessing active vitamins.

A further point of interest may be mentioned in connection with the investigation of the oxidising enzymes of many fruits carried out recently by Mrs. Onslow.[4] This observer finds, that fruits such as apples, peaches and plums, the flesh of which readily turns brown on exposure to air, contain oxidising enzymes of an active nature, whilst others such as oranges, raspberries and lemons do not. If one glances down a list showing the relative antiscorbutic potencies of these fruits, it will be seen at once that those which contain the oxydases are the less powerful in antiscrobutic effect. So far as the evidence goes, the same seems to hold true for vegetable juices.

[1] Report on Accessory Food Factors, London, 1919, p. 37.

[2] Myers and Voegtlin, *J. Biol. Chem.*, 1920, 42, p. 199.

[1] Harden and Zilva, *Lancet*, 7th September, 1918.

[2] Zilva, S. S., *The Lancet*, 5th March, 1921, p. 478.

[3] Hopkins, F. G., *Biochem. Journ.*, 1920, xiv., p. 725.

[4] Onslow, M. W., *Biochem. Journal*, 1919, 1920, 1921.

It will have been noticed, from what has already been said, that there is no reliable chemical criterion of the presence of a vitamin. At present the only real test for the activity of a solution lies in its effect when administered to an animal, either as a part of a controlled diet, or as a curative dose; and this brings us to the second line of work on vitamins—the biological.

(*b*) *Biological Methods.*—Biological experiments with vitamins are usually carried out on appropriate animals, but of recent years attempts have been made to show that certain plants can also be used.

(1) *Experiments on Animals.*—Experiments on animals are either designed to be curative or preventive in the case of the vitamins B and C where specific diseases follow deprivation. In the case of both B and A, deprivation of these elements in the case of young rats may check growth before any specific disease appears, and Drummond has attempted to obtain a quantitative relation between different sources of A, and, by studying variations in the growth rate of young rats brought up otherwise under similar conditions.

In practice the presence of vitamin A is generally tested on young puppies, kittens or rats; B is usually tested on fowls or pigeons, but frogs have also been used; and C has been investigated more particularly by the use of guinea-pigs and monkeys, although certain observations have also been made on swine, and on milking cows. In each case it will be obvious that the result depends largely upon a thorough knowledge of the care of the animal concerned, upon close observation during the experimental period, and upon having healthy, normal animals, previously reared under similar conditions, so as to provide initial uniformity as far as possible at the outset.

Qualitatively we can prove the presence of vitamins in foodstuffs in most cases without great difficulty.

Thus pigeons fed on polished rice develop polyneuritis in 15 to 25 days, with paralysis of legs and wings, death following, if unrelieved, in one to two days later. In curative experiments a bird in this condition is fed through the mouth with varying amounts of the substance to be tested. In this disease the cure, even in severe cases, may be very rapid. Of all curative substances rice germ has been found to be the most efficient, wheat germ lentils and pressed yeast being also very effective. Preventive experiments have also been planned from time to time, an additional substance being added to a rice diet and the result being watched. With delayed symptoms some active vitamin is indicated, but if health is maintained, a greater activity or a greater amount of a less active substance is indicated.

It is obviously difficult to get any very accurate notion of vitamin content from such "pigeon analysis," but in spite of this the results have been of considerable service in pointing the way to more perfect diets for human beings, especially in regard to the prevention of beriberi, the disease in man which closely parallels avian polyneuritis.

In the case of the antiscorbutic factor, or vitamin C, much work has been done on young guinea-pigs as well as on monkeys. Young healthy guinea-pigs of about 300 gm. weight (*i.e.*, about 6 to 8 weeks old) succumb to scurvy in about a month in a diet complete excepting for the total absence of antiscorbutic elements. With supply of a small amount of antiscorbutic, partial protection may be achieved, and a condition of chronic scurvy, which, given efficient care in feeding, and absence of intercurrent disease, may be almost indefinitely prolonged.

As the result of a large number of experiments mainly in England and America, the distribution and relative activity of a large number of fruits, vegetables and a few commercial products has been determined. In a few cases their behaviour on heating, drying and storing has also been ascertained. There is evidence, however, that the antiscorbutic value of a vegetable or fruit may vary with its condition—for example, young carrots are more effective than old ones, and ripe tomatoes than unripe. Since in most processes of manufacture (drying or canning, *e.g.*), antiscorbutic vitamin C suffers much destruction, the resulting product may have very little or no remaining active vitamin when reaching the consumer. Orange juice has, however, been successfully dried in America with little loss in value.

Much valuable work has been done on the vitamin content of milk and milk preparations. Although containing all three vitamins A, B and C in the fresh conditions, the vitamin C is present in initially small amount, and is apt to deteriorate not only with the drying process, but with the subsequent storage before use. Moreover, recent observations carried out on milking cows prove what has long been suspected, namely, that the previous diet of a cow affects either the quality or the quantity of the milk produced. Hopkins finds that a diet deficient

in vitamin A caused the milk yield of a goat to fall off, the quality remaining the same. Hart, Steenbock and Ellis,[1] on the other hand, found that cows stall-fed and kept without green food for years produced milk similar in quantity, but very inferior in antiscorbutic quality to grass-fed cows.

The demand of the animal body for vitamin C varies much with the species. Thus guinea-pigs require about as much antiscorbutic to retain their normal health as monkeys, with a body weight nearly ten times greater. Rabbits and rats need apparently very little antiscorbutic, and never manifest symptoms of typical scurvy, although their health and growth appear to suffer in a general way when deprived of antiscorbutic foods.

A brief reference must be made to experiments on young growing animals, such as rats, and the vitamins B and A.

McCollum and Davis, in America, succeeded in demonstrating that the normal growth of young rats, kept on a balanced diet of highly purified foods, could not be maintained unless certain additions were made, which they termed accessory food factors, and distinguish as watersoluble B and fatsoluble A. There is little doubt that McCollum's watersoluble B is identical with Funk's antineuritic vitamin curing polyneuritis in pigeons, and the term, "Vitamin B" (of Drummond), is used, assuming the identity of these two substances. In the same way, McCollum's fatsoluble A has been re-named by Drummond vitamin A, and is regarded by many as an active factor in the prevention of rickets in young puppies and in infants. Evidence is not, however, conclusive on this point. Mellanby[2] finds, for instance, that while young rats cannot make appreciable growth when vegetable oils form the only possible source of vitamin A, yet some of these same vegetable oils are able to prevent rickets in puppies, namely, peanut, cocoanut and cottonseed oils. According to Mellanby this may be explained partly by supposing that children and puppies need relatively less of A to prevent rickets than rats need to promote growth, and partly by taking into account the composition of the rest of the diet. Thus, of three puppies of the same litter, the one which had eaten most largely of starchy food was found to be the first to show signs of rickets. A diet

[1] Hart, Steenbock and Ellis, *Journ. Biol. Chem.*, 1920, Vol. 42, p. 383.

[2] Mellanby, *Lancet*, 7th April, 1920, p. 856.

rich in protein appears to need less additional vitamin A than one rich in carbohydrate on this theory.

To obtain a *quantitative* estimate of a vitamin in a foodstuff is a much more difficult matter. Since these substances cannot be estimated by extraction, some indirect method must be used, based on the observed effect of a known amount of a food or a solution on an animal under controlled conditions of experiment.

This has been done with some success in the case of vitamin B by Chick and Hume,[1] who found that unheated wheat embryo to the extent of 1 to 2·5 gm. was just sufficient to cure avian polyneuritis, whereas after heating for 40 minutes in an autoclave at a temperature varying from 100° to 117° C., the least amount necessary to bring about a cure of similar birds was a 5 gm. dose. By this method a partial destruction of the curative power, and therefore presumably of vitamin content, is clearly demonstrated.

In the case of the antiscorbutic vitamin C, quantitative data of a similar kind have been obtained by finding the minimum daily antiscorbutic ration of fruit or vegetable necessary to protect a young guinea-pig or monkey from scurvy. The actual amount needed will vary somewhat with the basal diet used and perhaps also with the weight of the animal, but by using the same basal diet, and animals of similar initial weight, fairly consistent results may be obtained, and a comparison instituted between different substances, or the same substance under different conditions. Thus a minimum protective ration for young guinea-pigs has been determined[2] in the following cases amongst many others:—

fresh, raw	orange or lemon juice	1·5 to 2 c.c. daily
	tomato juice	1·5 c.c.
	swede juice	2·5 c.c.
	cabbage (green)	1c.c. to 1·5 c.c. daily.
heated 1hr. at 100° c.	orange juice	1·5 c.c.
	swede juice	5. c.c.
	cabbage juice	5 c.c. to 7·5 c.c.

This shows at once that amongst substances having the same or nearly the same original value, very different effects are produced by heating. The explanation of the different stabilities in these cases is not yet forthcoming, but is probably connected with oxidative capacity.

One of the great difficulties which is involved in the attempt to measure the growth

[1] Chick and Hume, *Proc. Roy. Soc.*, 1917 B, 90, p. 60.

[2] Delf, *Biochem. Journ.*, Vol. XIV., April, 1920, p. 211.

promoting power of any substance containing fatsoluble A lies in the choice of standard conditions for the measurements of growth. Drummond and Coward[1] have recently made great progress in this respect. After considering the production of a more or less uniform type of experimental animal by breeding under the same conditions, and after choice of a suitable basal diet for all, these authors come to the conclusion that the rats used should be showing about the same initial rate of growth. A rat four to five weeks' old, weighing 50 to 70 gm., shows scarcely any increase of weight after two weeks of a balance synthetic diet of highly purified constituents. If, when the test substance is added growth occurs, the substance may fairly be assumed to possess growth promoting properties due to the presence of vitamin A. Evidence has been obtained showing that as a rat approaches maturity the amount of vitamin A needed to restore growth which has been checked on a deficient basal diet is inversely proportional to the body weight of the animal. Observers, therefore, who have used nearly full-grown rats would be led to ascribe a higher vitamin value to a test substance than would one who used younger and more rapidly growing animals. This important contribution to our knowledge of the behaviour of vitamin A in respect to growth has a three-fold interest. It explains, at least in part, the conflicting results of certain English and American workers: it is an important step towards a quantitative estimation of vitamin A in different foodstuffs, and if the relation asserted between vitamin need and body weight be confirmed, it forms a striking contrast in this respect with the antiscorbutic vitamin, the need for which appears to increase rather than decrease with increase of body weight.

2. *Experiments with Plants.*—Since the method of observing growth or disease in animals involves much expenditure of time and labour before results can be attained, various attempts have been made to utilise plants for this purpose. Green plants are generally supposed to manufacture their own vitamins, but in the fungi Saccharomyces (yeast) and Aspergillus (blue mould) some indication has been obtained that addition of a solution containing vitamins will visibly stimulate the growth of a pure culture, otherwise only supplied with mineral salts.

[1] Drummond and Coward, *Biochem. Journ.*, Vol. XIV., December, 1920.

According to Williams[1] (1919, 1920) the watersoluble vitamin B is necessary for the nutrition of the yeast plant. In the first method used, yeast from a pure culture was placed in a refrigerator for a day or two before use. It was then transferred to a previously sterilised nutrient solution placed in drops on a hollow microscope slide. The drops were examined microscopically, their contents being noted; incubated for 5 to 24 hours and re-examined. Subsequently, larger quantities of solution were inoculated from the pure cultures and small amounts of the substance containing vitamin were added. If 1 mgm. added substance produces in culture on incubating 8 mgm. more yeast than control, the "vitamin number" is 80. This very definite attempt to use growth of yeast as an indicator of the activity of a solution containing vitamin B has been adversely criticised by subsequent writers,[2] and can hardly be regarded as a safe indication at the present time. Williams states that vitamin A does not affect the growth of yeast. About the same time Eddy and Stevenson[3] made the claim that the growth of yeast may be stimulated by the antiscorbutic vitamin, and they hope to make the method also quantitatively dependable.

3. *Experiments in Vitamins in Relation to Human Deficiency Diseases.*—Under certain conditions experimental work on the human subject is justifiable and indeed often inevitable. Thus, as long ago as 1747 Lind made trial of various methods of curing scurvy on a ship at sea, and found that, of all methods tried, the "most sudden and visible" effects were from the consumption of two oranges and a lemon daily. After six days on this treatment two of the worst cases were fit to resume duty. Cider had also a beneficial effect, and caused decided improvement, though not recovery, after a fortnight's use.

In recent years the war conditions over large areas have provided ample opportunity for applying laboratory experience to human subjects. One of the most striking cases of this has been the use of pressed yeast cake to cure beriberi in the East during the late war. Another case is the use of germinated pulses in the cure of scurvy—a method

[1] Williams, *Journ. Biol. Chem.*, 1920, Vol. XLII., p. 259, and *Journ. Biol. Chem.*, 1919, Vol. XXXVIII.

[2] Fulmer, Nelson & Sherwood, *J. of Amer. Chem. Soc.*, January, 1921, Vol. LXIII., p. 186.

[3] Eddy and Stevenson, *Journ. Biol. Chem.*, 1920, Vol. XLIII., p. 295.

which may assume importance in the absence of available fruit or vegetables. A number of Serbian soldiers with more or less severe symptoms of scurvy were treated by Wiltshire[1] in two lots. On the whole the worse cases were given a ration of 4 oz. (dry weight, *i.e.*, about ½ lb. fresh weight) of germinated beans, sprouted, and cooked not more than 10 minutes. A number of similar cases were given instead 4 oz. freshly squeezed lemon juice, sweetened, the remaining diet being the same. After one month 70% of the bean and 53% of the lemon juice cases were cured. The use of germinated beans in the prevention and cure of scurvy was suggested by previous laboratory experiments in Sweden and in England.

In 1920 Capt. Stevenson[2] reported on his treatment of over 300 cases of scurvy in one of the prison hospitals in a small island off Archangel. He grouped the cases, treating all to the same basal diet, and adding as antiscorbutic one of the following to each group:—

(a) 4 oz. fresh lemon daily.
(b) Peas, germinated and cooked for ½ hr
(c) Beans, germinated and cooked for ½ hr
(d) Fresh meat—10 oz.—roasted and underdone.
(e) Tinned fruit—8 oz.
(f) Lactic acid milk—2 pints.

The fresh lemon juice, peas and milk patients were the best, improving markedly in two weeks' time.

In the same year an outbreak of scurvy in a hospital in Vienna was investigated by Drs. Chick and Dalyell,[3] and traced to the over-cooking of an otherwise barely sufficient vegetable ration. Further experiments are to be made in this institution, where one ward has been given to these workers, one of whom has been a pioneer in investigations on vitamins; whilst the other wards will be worked under the old system. Speaking of this venture Hopkins[4] says: "It is unique in its occasion, in its international character, and in the high qualifications of those who are to conduct it." It is hoped that this enterprise, backed as it is by the Lister Institute and by the Medical Research Council, will show the value of co-operation between the laboratory investigator and the medical practitioner.

[1] Wiltshire, Major H. W., *Lancet*, 14th December, 1918.

[2] Stevenson, *J.R.A.M.C.*, 1920, p. 218.

[3] Chick and Dalyell, *Br. Med. J.*, 9th October, 1920, p. 546.

[4] Hopkins, *The Lancet*, 1st January, 1921.

(*c*) *Physiological Methods.*—These aim at discovering the rôle of the vitamin in the animal body. There are two lines of work which have been followed in recent years. In one, histological investigations of organs of animals suffering from deficiency diseases are made; in the other substances known already to be physiological stimulants are tested on animals suffering from deficiency diseases, in the hope of producing recovery.

The great influence of the presence of vitamins in the diet on certain organs has been forcibly demonstrated in recent years by Mrs. Mellanby,[1] who found grave defects in the teeth of rickety puppies, and by Zilva and Wells,[2] who, about the same time, proved that lack of anticorbutic in the diet produced profound changes in the teeth of young guinea pigs. McCarrison[3] and others have demonstrated enlargement of the adrenal glands of polyneuritic pigeons and scorbutic guinea pigs; in the latter case changes in the bladder wall also occurring very early.

On the other hand, Dutcher[4] has found that certain physiological stimulants possess a measure of curative power in avian polyneuritis—such as dessicated thyroid gland, and pilocarpine hydrochloride. This suggests wide possibilities for future investigations, in the relation between vitamins and glandular secretions:

CONCLUSION.

In reviewing, even thus briefly, some of the numerous ways in which problems relating to vitamins, their distribution, their constitution, and their importance to life are being investigated one cannot help being impressed with the feeling that rapid advances may be expected in the near future, as the evidence from different lines of research converges to throw more light upon these elusive but most essential substances. We may expect that in the light of such knowledge improvements will be made in manufacturing processes involving the preparations and storage of food, rationing of institutions or of armies, and, last, but not least, improvements in our knowledge of the relation between a normal healthy diet and resistance to disease.

[1] May Mellanby, *Lancet*, 1919.

[2] Zilva and Wells, *Lancet*, 1919.

[3] McCarrison, *Ind. Journ. Med. Research*, Vol. VII., 1919, p. 279 and p. 308.

[4] Dutcher, *Journ. Biol. Chem.*, Vol. XXXIX., 1919, p. 63.

The Chairman: I think I voice the feelings of the members of the Society in saying that we are fortunate indeed in having such a splendid paper and lecture delivered before this Society by Dr. Delf on a subject which, although it may be somewhat new to a great many of us, is very fascinating. I think research in connection with this subject of vitamines will open up an avenue for a great deal of development, and will certainly lead toward a scientific and well-balanced diet. In its practical application it will probably come home to most of us, and I hope that we shall find that our favourite dishes will contain the necessary vitamines.

Dr. A. J. Orenstein: Mr. Chairman, ladies and gentlemen, I wish to associate myself with our Vice-President in congratulating the Society and Dr. Delf on the subject of to-night's paper. It is, as the Vice-President has said, probably a subject which is not familiar to the majority of members, but, nevertheless, it is a subject which touches everybody. Here in South Africa, and especially to those of us who are associated with mining and the incidental factor of dealing with a very large number of natives for whom we have to provide daily food, it is a subject of the greatest importance, not only from a humanitarian point of view—our obligation being to restore these people at least as well physically as when we withdrew them from their homes—but from the economical point of view. It so happens that about half our natives are recruited within the Union of South Africa, and a very large majority of these are recruited in certain areas of the Transkei where, for some years now, on account of the successive failures of crops, due to unusual dryness, the people are in a condition of what may be roughly termed latent scurvy. It is a fact which goes to support one of the theories of the action of vitamines that persons who do not do any great amount of work may live on comparatively small amounts of vitamines, but when they are called upon to do more or less heavy labour, the increase in the metabolism seems to create a greater demand for vitamines. The practical lesson of this is, that although a comparatively extensive search for scurvy in the native territories, carried out by Dr. Green and myself resulted in our seeing practically no cases of scurvy among the natives in their own kraals, these very same natives who, on medical examination, appeared to be free from scurvy, developed scurvy within the incubation period for a human something within the period of from two to six months —after being put to work on the Rand. It is also a fact that in 1920 there was as much scurvy, and a little more, than in all of the previous five years put together, both in cases and in deaths. It is, furthermore, a fact that in spite of—and I am sure everyone will agree with me in this—the great improvement made in the treatment of hospital natives and the treatment of wounds, sepsis has not decreased, to say the least of it, to such an extent as mortality has decreased, or perhaps has even relatively increased. It is also an interesting fact, in this connection, that people who have scurvy even so slightly as to be almost unrecognisable, are particularly liable to infection. So that we are losing in efficiency through scurvy, the country is losing in our sending back to the kraals people undermined in health, and we are further losing, a probably very much greater amount, by having a very large number of wound infections, which are perhaps—and I personally think they are—due to scurvy.

Furthermore, South Africa has another problem which is connected with vitamines, and that is in the Cape Colony especially, where coloured children, the children of mixed parentage, particularly in the slum areas of the larger cities, are stunted, undeveloped, sickly and ricketty, which is probably due to the absence of fat in their food. This is a problem of great national economic importance. The subject of vitamine investigation, as I am sure you have gathered from Dr. Delf's most interesting paper, is one the very fringe of which has only been touched in the last decade or so; it still leaves a very large field in which persons of various scientific attainments, such as constitute the membership of this Society, could in many instances co-operate and contribute towards a solution of the problem. In the problems of vitamines, the chemist and bio-chemist have a large field before them, and, as is shown in the case of the reader of the paper to-night, who is a botanist, even a botanist can do a great deal of that work, and the mining man, the compound manager, the mine manager, and all the rest, can contribute a great deal in the way of practical observation and practical application of theories developed in the laboratory to the test of every-day experience: Vitamines illustrate probably as much as anything in the recent development of laboratory work, its eminently practical nature. A great deal which at first glance

may seem to be purely academic in interest, has a tendency to develop into something which has a large field of usefulness. One can see, in connection with vitamines, that not only would the laboratory work be useful in finding the cure and prevention of human disease, but it may have a great deal to do with the development of agriculture. This country still has a very large area of undeveloped land; but the world is rapidly approaching the point when the problem of growing enough cereals to feed all will become a very pressing one indeed, and nothing which may tend to produce more than is grown to-day can possibly be ignored by future generations. Vitamines, if they are necessary, as appears to be *prima-facie* the case, to the growth of cereals and vegetables may become of huge economic importance.

I have always felt that a very good measure of the grasp of a subject on the part of anyone is ability to impart it in such a way that other people can grasp the essentials, and, I think, judged in that way, Dr. Delf's grasp of her subject is extraordinarily good. I have pleasure in moving a vote of heartiest thanks to Dr. Delf for her paper.

Mr. C. J. Gray: I have pleasure in associating myself, sir, with the remarks that you and Dr. Orenstein have made with regard to this paper. This evening is an important one in the history of the Society for more reasons than one. One reason is that we have been addressed by a lady, a lady who has entered into our scientific labours. I am sure we all agree that the field of science and technology before us is so wide and the matters for investigation are so scattered and so extensive, that it would be a great pity if such work were left to one sex only.

The second reason why we should welcome this paper is its intrinsic value. It deals with a subject which is attracting a great deal of attention in the world. No one can read scientific journals without coming across mention of vitamines and their importance. It is also a departure from the chemistry of the past. We used to hear of carbo-hydrates and other food materials, but the chemistry of foodstuffs did not seem to make any very great advance. I take it, though not a chemist, that the discovery of the importance of vitamines alters the whole position, and that now there is hope that we shall get real knowledge of our foodstuffs. Really, we have been extraordinarily ignorant; it seems strange to think how we have accepted our foods; we have eaten foods simply as we saw fit without the slightest regard to whether they were of value to us or not, or which of them was of the most value. In the future, as research goes on and our knowledge extends, the position will be very different.

The third reason why we should welcome this paper is the new departure it makes in the work of this Society. The Society is a Chemical, Metallurgical and Mining Society. As far as mining is concerned, we have constantly stretched out into those fields of research which deal with the vital interests of man: questions of health and safety. I think the chemical papers of the past have dealt with matters of pure science, and more particularly with economic questions, but the paper that we have had this evening opens up a further field, and brings chemistry into line with mining, in dealing with questions of life and health. If the two wings of the Society can join in bettering the condition of mankind, then we shall have made a great step forward. I have pleasure in seconding the vote of thanks to the reader of the paper.

Professor C. E. Moss: As a non-member of your Society, sir, I have pleasure in supporting the resolution. Dr. Orenstein referred to the lecturer as only a botanist, and I am in the same unfortunate position. I have greatly enjoyed this lecture from many points of view.

There is the human point of view, to which all the speakers have so far referred, viz., the effect of vitamines on ourselves. One cannot help looking back some years, and considering the advice which was once given us as to what we ought to do with our foods. First of all, we had to heat them to a high temperature to get rid of animal parasites and harmful bacteria. Now a great many foods we have not to cook at all, for fear of robbing them of valuable vitamines. I have no doubt, as research in this subject proceeds, we shall have lists of foods given to us that we have to cook, in order to kill the injurious parasites and bacteria, and other foods which we have not to cook in order to retain the maximum number of valuable vitamines.

It is interesting to note that Dr. Delf pointed out that the chemical composition of vitamines was unknown. It is rather like the green colouring matter in plants, which is, I suppose, the most important chemical compound in the world. Yet it is only a few years ago—just a year or two before the war—that the chemical composition of that

substance was made known. Perhaps in another quarter of a century we shall have a paper before this Society, wherein the chemical composition of vitamines will be revealed to us.

Although this is such a new subject perhaps in South Africa there is already one local industry which is in danger on account of researches in connection with vitamines. I mean the marmalade industry. It seems, in boiling the fruits in this manufacture, the necessary vitamines are destroyed. That is a serious danger for one of South Africa's young industries. I would also like to refer to a more personal matter. A little over four years ago when I left England to come out here, I left Dr. Delf behind, at Cambridge, as a colleague, carrying on her researches in botany, and very shortly afterwards she took up her present study as a war subject; and it is one of the interesting results of the war that our knowledge of vitamines has progressed very considerably.

I would like to associate myself with what the preceding speakers have said about the enjoyability and general excellence of the lecture from all points of view.

NATIONAL RESEARCH COUNCIL.

The Chairman: We have with us this evening Dr. van der Bijl, the Scientific and Technical Adviser to the Department of Mines and Industries. He wishes to address the meeting on a subject which will interest us very much. I have pleasure in introducing Dr. van der Bijl.

Dr. H. J. van der Bijl: Mr Chairman, ladies and gentlemen, my message is short, and I won't detain you long.

At the outset, I may say that I am here to see what can be done to help along the industrial development of South Africa. What I have to say to you to-night is what I want to say to other scientific, technical and engineering societies in South Africa, and it has to do with one of a number of phases that fall within the scope of my work.

As you know, the industries of this country have developed at what we might call a phenomenal rate during the past eight or ten years, and I think that many people have lost a certain amount of scepticism regarding the industrial future of this country, and at least a good start has been made. But at the same time, we must not forget that this remarkable development has taken place under very abnormal conditions, and we shall, sooner or later, find that we shall have to compete with other countries on industrial grounds—that is, if we hope to approach anything like economic independence. And then we shall for various reasons find the need for carrying on scientific research.

The wide application of scientific research methods to industrial development in more highly developed countries has made it practically impossible to-day for most industries to withstand present-day competition on existing knowledge; that is, the constant need for scrutinising existing conditions, improving methods and processes of production, always trying to produce a better article at a lower cost, getting more work for the money paid, and so on, has brought about a general recognition of the value of facilities that could make possible the creation of the knowledge necessary for effecting these improvements.

The high state of competition which we find existing in other countries has been brought about to a large extent by the wide application of scientific research.

The application of scientific research to industrial development is as old as the industries themselves, but what is comparatively new and has been recognised only in the past 10 years, more or less, is the value of *organised* research. Research is capable of being organised like any other industrial or commercial undertaking. I have spent about eight years in organising and conducting research in the United States, and I know that, if it is properly handled, it can be made a very well-paying proposition. The organisation of research must be based on two conceptions: firstly, it is to-day impossible to draw a definite line of demarcation between any two branches of science. We have seen it here to-night; I suppose Dr. Delf who, I believe, is a botanist, has found that a knowledge of chemistry is very helpful in her study of vitamines, and, if she goes much further, she will probably feel the need for a knowledge of physics or at least the help of physicists, and finally the chances are that vitamines may still demand the labours of mathematicians before we can really know what they are. You can take up hardly any study without getting into almost all branches of science; that is, if you try to carry out real research. The other conception is, it is impossible for any one man at the present time to be an expert in more than a comparatively narrow field. For those reasons, if you wish

to carry on real scientific research work economically, you have to organise it on a comparatively large scale. You must get together a number of men, each of whom is an expert in his own line of work, and let them work together in such a way that each one does the work falling within his sphere. That wide application of organised scientific research to industries is the very thing which causes a difficulty we have in South Africa. We are a small country with a handful of people. Most of our industries are very small, and are not in a position to organise large research laboratories. Consequently, they will find it difficult to compete with bigger countries where research can be organised on a large scale.

I have in mind the establishing of a central research institution which could do a lot of work for the country as a whole. The functions or the work to be carried on in such an institution could be broadly classed into three main classes, viz.: firstly, the study of problems that may be regarded as being of national importance, secondly, study of problems that have a more or less specific bearing on the industries; and, thirdly, the very important matter of testing materials and products and standardising instruments and specifications. We have nothing in this country like the Bureau of Standards in America and the National Physical Laboratory in England, or the Phisikalish Technische Reichsanstalt in Germany; and, I think, sooner or later, we shall find the need for such an institution.

I want to approach you with regard to research problems that could eventually be carried out in such an institution, and I may say that to establish such an undertaking without our scientific and technical societies at least knowing something about it would be a mistake; we might get something which is not what it should be. It would be—well, I won't say dead, but it might not be the live animal I would wish it to be.

While I am not in search of problems, I should like to have those problems that have presented themselves from time to time, co-ordinated and sifted, so that we can obtain a better grasp of existing conditions. The engineers and scientists of this country must have come across problems in their work which they may consider it important to investigate, and amongst these there are probably matters that may be regarded as being of national importance. If you were to ask a man off hand if he knows of any such problems, he might not be able to mention any just then, but if he kept the matter in mind for, say, a week or two, he might be able to furnish quite a few. If engineers and scientists would keep this matter in mind for some time, we should probably get more problems than we could handle; but we wish to develop the natural resources of the country in the most expeditious and efficient manner, and if we have a co-ordinating means where these problems can be set out, we shall be fairly sure that we shall attack first the more important ones.

Therefore, I would suggest that your Society form as the others, I hope, will do, a Committee, which may be called a Research Committee, and to which problems could be sent by any members when they think of them. Later on, such a Committee could take a more active part in co-ordinating these problems and then letting me know about them. I think it will be of great value if these problems be brought through one channel in that way.

I may say that I do not like the idea of always creating new bodies for doing things; but I have in mind a matter of co-ordination rather than the creation of a new body. You know that there is in existence a Research Grant Board, which was formed by the Government; and what I have in mind is not in any way going to conflict with the functions of the Research Grant Board. For this reason: the Research Grant Board does not represent all the scientific and technical interests in the country; it is comprised of some of the best talent we can get together; and, when a man has a problem that he would like to investigate, he writes to this Board and tells them what he plans to do and what it will cost. He asks for the necessary money, and he sometimes gets it —he either obtains a grant-in-aid of research or a scholarship. What I have in mind here is the opposite process, namely, not handing out scholarships or distributing problems for people, but bringing problems together.

Recently an International Research Council has been formed for the study and co-ordination of various problems and interchange of views amongst scientists, and the Union of South Africa has been asked to join this International Research Council. The question which came up was how we could join. A country can join through its National Research Council or other body which represents the whole country, or through the Government. As far as I can make out, we have no body representing all

the interests, scientific and technical, in the country. To have the Government join directly would not have the desired effect.

If we formed Research Committees in the various Societies, these Committees together, or delegates from them, could be formed into a National Research Council. We should then not be placed in an embarrassing position when asked to join the International Research Council, because we should have a body representative of the whole country's scientific and technical interests. In conjunction with this International Reseach Council, there have also been formed the International Unions; there is the Union of Astronomy, the Union of Pure and Applied Chemistry, of Geodesy and Geophysics, and so on. These interests would be represented on the proposed central body, and it would be an easy matter then to join the respective International Unions.

I have put before you two things. One is the formation of a Research Committee which could act as a body for receiving ideas regarding research problems that are of national importance, and also problems more or less directly affecting the industries, and the other is the idea of forming a National Research Council in South Africa. We may not feel the need of such a body at the present time because South Africa is doing little in the line of research. I think the secretarial expenses of such a body would be for the present very small; but, as the time goes on, I feel sure, say, in five or ten years if the country develops as we hope it will, we shall feel the need of such a body very much, and I hope you will see your way clear to do something in this direction. A start, at least, should be made now.

In conclusion, Mr. Chairman, I wish to thank you for having given me the opportunity of mentioning this to you.

The Chairman: I am sure that the Society will give sympathetic consideration to Dr. van der Bijl's proposals. I should like to ask him whether the formation of the Committee should precede the establishment of a Government Research Laboratory, or should the Laboratory come first, and whether he thinks the formation of Committees by this Society will strengthen his hand in obtaining the Laboratory.

Dr. H. J. van der Bijl: Yes; it will strengthen my hand. Some research work is being carried out at University Laboratories; and, I think, if we want this country to develop industrially, our Universities must be raised to the true standard of Universities. They should be in a position to carry out a considerable amount of research.

The Chairman then spoke of the question of forming a Research Committee, and invited the opinion of the meeting as to whether such a Committee should be formed at the meeting.

It was unanimously agreed that the matter be left for the Council to deal with.

SYMPOSIUM: MINERS' PHTHISIS.

DUST PREVENTION.

Mr. E. S. Hendrikz (*Assistant General Secretary S.A. Mine Workers' Union*): Mr. Chairman, ladies and gentlemen, I feel a bit out of my element to-night, being in the company of what I might call the upper ten of the working class. The miners, as you are aware, are a curious compound of human nature, one of those compounds being suspicion, and I am afraid when they come to learn that I have been fraternising with the upper ten, it may create suspicion; but, seeing that I am here in a common cause, that is, in connection with the phthisis question, probably they will forgive me.

I regret I was unable to be present at your last meeting, but I can assure you, I closely studied the Minutes of the meeting, and I was greatly impressed with the short essays which were given at that meeting.

The question of miners' phthisis is rather a broad one to deal with, for, to go into the whole question would probably take up the whole of the evening. So I am confining myself more or less to dust prevention this evening. I am not a technical man; I am only giving you my opinions and impressions as an ordinary miner.

The question I am particularly dealing with to-night will be that of certain attachments and devices which are in the market to-day for minimising or eliminating dust underground; attachments and devices which can be applied to any of the machines in use underground at the present time. But, up to the present, the Government and the industry have failed to give these practical trials, and it is more or less on those lines that I am giving you a short paper this evening.

A great deal has been done in the past, but there still remains a great deal to be done for the purpose of eliminating dust

underground. Water has been plentifully used. Rock drills have been introduced with hollow steel, allowing a jet of water to pass through the steel direct into the hole, but, in spite of all that has been done, we are still to-day faced with the fact that phthisis is very prevalent, and the time has now arrived when the professional and technical men of South Africa should seriously take this question up and do everything in their power to enlist the sympathies of the Government and the industries concerned with a view to solving the problem.

I can state with assurance that the majority of the miners would rather see greater efforts than hitherto made for the elimination of dust than to receive compensation for contracting phthisis, because compensation, however great, must always be inadequate. In other words, the men would sooner have their health and long life than £ s. d.

I am pleased to see that Mr. C. J. Gray, Inspector of Mines, Johannesburg, in a very able paper, deals more or less with the question of "what remains to be done to prevent miners' phthisis." He deals with what he calls "the human factor—good ventilation, water service for dust allaying purposes, etc.," and it is therefore not my intention to touch on these questions. I will, however, confine my ideas to one or two devices at present on the market, which I maintain should be given a fair trial under ordinary working conditions, and independent dust samples should be taken at regular intervals with a view to finding out whether the advantages of these devices or attachments are all that is claimed for them. Pressure should be brought to bear on the Government and the mining industry to give these a fair trial, and if it is proved that they produce a minimum of dust compared with other machines, the mining industry of the Witwatersrand should be compelled to introduce them throughout the whole of the Reef.

During the existence of the Miners' Phthisis Prevention Committee, a great number of dust samples were taken by the Government samplers in connection with a certain device or attachment, and from reports circulated by the Committee on the dust samples taken, it was proved that there was practically no dust from drilling operations and it was impossible for fogging to occur on account of the system of the engine—packing in the front end of the cylinder—which entirely prevented any water from entering the air cylinder. At the same time, it was claimed that the packing acted in a way which prevented any air from entering or blowing out at the front end of the cylinder, as is usually the case with the reciprocating machine. I do not intend to deal with the economic factor of the attachment in question, but purely with the question of its claim for the minimising of phthisis dust. From a report received from a Committee especially appointed by our Union to go into the question of one of these safety devices which can be attached to any Holman type machine at a very small cost, and other reports from miners who have used these attachments, it appears that owing to the mechanical structure of the attachment, no fogging takes place. We are of the opinion that the fogging created by machines at present in use is a great drawback to the health of the miners, and it may perhaps be the indirect cause of the miner getting phthisis. From practical experience I should say that the miner working continually in a foggy atmosphere underground is more susceptible to phthisis than if there were no fogging present.

In a letter received from the Secretary for Mines and Industries some time ago, he stated on the question of machines which create fogging, "that there is no objection to such machines if the fog consists of drops of water not containing silica particles in injurious quantity. If, therefore, the fog arises from the atomization of sufficiently clean water there can be no danger in so far as silicosis is concerned. The method of the determination of the amount of silica in the air is the same whether the air is foggy or not." From practical experience, however, I must say it is almost a matter of impossibility to get sufficiently clean water underground. Therefore, this argument falls to the ground. I am fully aware that no machine or attachment can entirely prevent the creation of dust because you cannot cut rock without creating dust. We can only aim at the utmost possible reduction in the creation of dust and the prevention of its distribution in the atmosphere. The problem before us is to take the machine or attachment which passes the least amount of dust into the atmosphere, and to exclude other machines. My union at various times have approached the Government Mining Engineer and the Chamber of Mines with a view of having at least one of these attachments tested under ordinary working condi-

tions, and at one time, representatives of the Chamber of Mines undertook to place 100 of these converted machines on various mines along the Reef, and to have dust samples taken at regular intervals. But, unfortunately, the Chamber up to the present has done nothing further in the matter and I think the time has now arrived when a definite stand should be taken in the name of humanity, compelling the Government and the industry as a whole to give these attachments or devices a fair trial. I would suggest that the trial should take place under ordinary working conditions under the direct supervision of technical men appointed by the Government, and, further, that the Government appoint impartial dust samplers whose duty it will be to continually take samples wherever these attachments are being used and report to the Government Mining Engineer. If, after a fair trial, it is found that these converted machines create no dust or practically none, the industry should be compelled to scrap all machines not fulfilling requirements, and adopt those which create the least dust. The initial expense of converting all the machines in use at present would appear to be a heavy burden on the industry, but that would be counteracted by the effect on the phthisis compensation moneys now being paid out by the industry. As you are aware, the Phthisis Board is at present paying out very large amounts as compensation, and if these attachments are found to be a success, a great portion of this amount would be saved by their introduction and, in addition, there would be a great reduction in the suffering caused and a large decrease in the death roll of both white and coloured workmen.

If machines, attachments, etc., are placed on the market, and it is claimed that they create a smaller percentage of dust than the machines at present in use, it is the duty of all professional and technical men to bring their influence to bear on the mining industry and the Government to give such attachments, etc., a fair trial. At the present moment we are faced with the position that the only way to force the industry to give such attachments, etc., a fair trial is to make phthisis as expensive as possible for the industry, and then perhaps it will realise that it is cheaper in the long run to try and eliminate dust from underground than to pay compensation.

In conclusion, I wish to point out that a large percentage of the underground workers to-day are not fully conversant with the risks they run in neglecting to carry out in full all the rules for the prevention of phthisis, and I think this Society would serve a very useful purpose if they could arrange a series of lectures with illustrations all along the Reef with a view of educating the men on the dangers of neglect in taking the necessary precautionary measures for the prevention of phthisis.

The Chairman: I should like to thank Mr. Hendrikz, on behalf of the Society, for presenting the mine workers' angle of view on this subject. I think the Symposium is fulfilling its purpose in bringing to light the ideas of various men. We have listened with great interest to Mr. Hendrikz' paper.

Mr. E. M. Weston: I did not mean to say anything on this subject, but some remarks made by Drs. Orenstein and Mavrogordato have encouraged me once more to place before you what I believe to be the correct view on this matter. In giving evidence before the Phthisis Commission, I maintained that other methods of protection were necessary. These medical gentlemen say that other methods are needed, even admitting that great progress has been made. Dr. Mavrogordato is evidently feeling round for them.

The question I want to bring forward is that of respiration. You know what the official estimate of all respirators was: in the first place the opinion was that no one would use them. At the time that pronouncement was made, I know personally, and miners can bear me out, that though the respirators were imperfect, they were often used during the shift by a considerable number of miners. When the official verdict came out that respirators were stopping only from 30% to 60% of the dust, their use was discouraged. My contention has always been that if a man wore a respirator which stops only 60% of the dust, he is going to increase his expectation of underground life by 60%.

As you know the older type of respirator has grave drawbacks; it was stifling, and there was no free breathing through it. About the time Sir Robert Kotzé invented the konimeter, I had the idea that if you could intercept the air on its way to the lungs with sticky baffles, and if you could impinge the air on them, an efficient respirator could be devised. My point has

been this, that it is not necessary to wear a respirator all through the shift, but that there are certain times and places during the shift when the wearing should be compulsory.

I made quite a number of models and gradually improved them. Dr. Moir kindly tested some for me, as also did Mr. Boyd. The efficiency with the gravimetric test was up to about 95 %. On the whole, as far as the gravimetric results go, they were most encouraging, inasmuch as one could stop nearly all the dust by impinging it on a sticky surface. Sir Robert Kotzé does it by impinging with high velocity, and there is no reason why it should not be done in the way I suggest.

Mr. W. Allen: With regard to Mr. Hendrikz' notes, he said the Chamber had offered to put 100 machines of the type described on the mines of the Rand. I may say as far as the Crown Mines are concerned, I have sixteen machines working on the No. 7 section. Dust samples are taken close to these machines, and, on the return airway side, and in places where dust is likely to be found. It does not appear from the samples that they give any better results than other machines. Another thing is, they have the same defect as the water Leyner; that is, the jumpers very often choke, and the boys promptly take the water hose off the machine and use it in exactly the same manner as for the solid steel one. There seem to be very grave defects in the machine as it is at present.

Mr. H. C. F. Bell: It strikes me in this dust question one point has been overlooked; that is, at the time when the holes are being blown out—it takes ten minutes in the development drive to blow out all the holes—more dust is created and inhaled by the miner and his boys, I should say, than is created and inhaled in a drive when drilling in a mine. It seems to me miners' phthisis could be reduced considerably if some patent scheme could be devised by which the dust or mud in the holes could be drawn out by suction, or some means by which it would not be dispersed into the air. I put the idea before the meeting, because it seems to me it is a point which is always overlooked.

NOTES ON THE INFLUENCE OF SOLUBLE SILICA AND CALCIUM SALTS ON PRECIPITATION.

By J. Hayward Johnson (Member of Council).

(Printed in Journal, October, 1920.)

DISCUSSION.

Mr. C. Toombs: Since Mr. Johnson's paper was written I have had the opportunity of examining a few zinc box products.

White precipitate nowadays differs considerably from the white precipitate of bygone days, which created so much discussion among chemists at that time. I find that to-day it consists largely of hydrated zinc oxide, with some zinc carbonate, calcium carbonate, sodium zinc ferrocyanide, and a few other substances, but hydrated zinc oxide predominates, and amounts to about 70 %. This explains why the precipitate is largely soluble in dilute sulphuric acid. I should say that the formation of hydrated zinc oxide in the boxes to-day is largely due to the very low cyanide strength and consequent low causticity of the solutions as compared with years gone by, zinc hydrate being soluble in excess alkali and thrown out of solution as neutrality is approached.

Calcium carbonate, too, is constantly depositing. Some of this naturally is formed by the action of atmospheric carbon dioxide, but on some of the mines there is a constant deposition taking place due to the reaction between calcium sulphate contained in large quantities in the reduction works water, and soda carbonate constantly being formed by the breaking up of the sodium cyanide in the works solutions. The solubility of calcium sulphate is, roughly, 2 gm. per litre, or 20 lb. per 1,000 gallons, and many of our mine waters are super-saturated with calcium sulphate owing to the use of lime in eliminating sulphuric acid, and salts of iron. Where such waters are used the precipitation can never be so good, nor will the zinc do without dressing so long, as in plants favoured with a good water supply. On the E.R.P.M. our industrial water varies from about 14-15 lb. $CaSO_4$ per 1,000 gallons in summer, up to the 18-19 lb. per 1,000 gallons in winter, and during summer months precipitation is fair, whereas in winter it is a

constant source of worry, and, in my opinion, this is largely due to deposition of calcium carbonate. $CaSO_4 + Na_2CO_3 = Na_2SO_4 + CaCO_3$.

Sodium zinc ferrocyanide is always with us, but fortunately is practically all removed in the treatment tanks, but for some unknown reason a trace is constantly forming and depositing in the precipitation boxes.

Silica is always found in gold slime, and other zinc box products, and is generally put down to imperfect classification, broken matting, and drift sand carried by the wind. Undoubtedly all three of these causes contribute from time to time to the silicious content of zinc box products, and this silica is present as insoluble or fixed silica. Silica may also be deposited as gelatinous silica (hydrated silicic acid), soluble in excess of alkali, also as combined silica, or silicate compound, both possibly coming from the same source. On the East Rand the natural waters of the district all carry more or less soda carbonate in solution, also sodium silicate. On coming into contact with acid mine water, this silicate is very largely broken up, and gelatinous silica set free. (Some time ago I had a sample of this gelatinous stuff brought to me by an underground man who was curious to know what it was.) Most of this form of silica finds its way to the sumps, but some of it forms in old workings, and when extensive reclamation work is being done some of it finds its way to the zinc boxes.

Combined silicate, such as sodium silicate, finds its way to the works in the water, and calcium silicate more or less water soluble is introduced by the lime used in treatment, more particularly in the hard burnt lime, generally called ball mill lime.

The presence of lead as sulphate in large quantities, in wet acid treated zinc box products, points either to a compound of lead, soluble in dilute sulphuric acid, such as carbonate, depositing on the zinc, or to a constant small deposition of lead sulphate, due to reaction between the lead nitrate or acetate used on the plant with the sulphates carried in the solutions. Which ever of these is the cause, its presence on the zinc is a factor towards bad precipitation.

A few months ago, after a period of very bad precipitation, it was found impossible to filter press the acid-treated material from the slime boxes. Suspecting silica to be the cause, I decided not to dry it completely, but treated it as follows:—

The sample was washed by decantation with distilled water until free from soluble zinc compounds, filtered and drained over night.

The gelatinous mass was transferred to a stoppered bottle, shaken up well, and the percentage of solids determined.

(a) A portion of the wet product was then treated with ammonium acetate solution, washed and the lead in solution determined as lead sulphate.

(b) The residue was digested with 5% Na_2CO_3, and the silica thus dissolved determined—gelatinous silica.

(c) The insoluble matter was heated with hydrochloric acid, neutralised with soda, and made up to 5% Na_2CO_3, digested and dissolved silica determined—silica in soluble silicates.

(d) The residue from (c) was treated with aqua regia, and the insoluble matter washed with ammonia to remove silver and the silica in the residue determined—fixed silica.

The following were the percentages found:

Lead sulphate	27·7%
Gelatinous silica	8·2%
Silica as silicates	4·4
Fixed silica	15·1%

Some sodium zinc ferrocyanide was also found.

Ordinary filter-pressed gold slime:—

Lead sulphate	21·9%
Gelatinous silica	2·8
Silica as silicates	1·8
Fixed silica	8·4%

This sample had been acid treated, but not calcined, and was washed free from zinc sulphate.

ORDINARY WHITE PRECIPITATE.

A sample of this contained 64% zinc hydrate, and was treated similarly. It was found to contain:—

Lead sulphate	5·5%
Gelatinous silica	1·2%
Silica as silicate	2·5%
Fixed silica	6·1%

A sample of precipitate which had settled in boxes containing no zinc contained :—

Zinc hydrate	68·0%
Lead sulphate	4·0%
Gelatinous silica	0·4%
Silica as silicate	2·3%
Fixed silica	7·6%
Calcium carbonate	9·0%

Gold, 92 oz. per ton.

The interesting feature in the above is the presence of lead sulphate in all of the samples, and it is quite possible that a film of this very finely divided substance may play a bigger part in causing bad precipitation than is generally recognised.

CEMENTATION OF THE SUBSTRATA OF THE MAZOE DAM RETAINING WALL.

By Dr. G. A. Voskule.

(Printed in Journal, November, 1920.)

DISCUSSION.

Mr. Weston: There is just one remark I should like to make in connection with this paper. According to the accounts I have had, they spent about £10,000 on cement, and the character of the rock shows there is a great deal of open space, and not much sand in the more fractured portions. It seems to me a mixture of one of cement and four of sand, or some other material of the same fineness and specific gravity, saving about three-quarters cement, would have been quite as effective as the pure cement in that instance.

Mr. Toombs: In reply to Mr. Weston, I would point out that the cement used in this work is ground extremely fine, and is put into the boreholes as milk of cement. A mixture of sand with the cement would not work, as the sand would settle out in the bore hole and block it up.

TREATMENT OF ANTIMONIAL GOLD ORE AT THE GLOBE AND PHOENIX MINE, SOUTHERN RHODESIA.

By Mr. V. E. Robinson.

(Printed in Journal, January, 1921.)

CORRIGENDUM.

On page 169, second column, third paragraph from the bottom should read :—
"On rearranging the plant to admit of this new treatment, I found that the sands with up to 40%—150 mesh leached sufficiently well to remove the soluble gold, and thus no slime plant was necessary."

OCCURRENCES OF FIRE-DAMP ON THE FAR EAST RAND.

By T. N. Dewar.

(Printed in Journal, February, 1921.)

DISCUSSION.

Mr. C. J. Gray: The following is an abstract from a letter received from Mr. J. Fairhurst, late Principal of the Wolhuter Government Miners' Training School, who had considerable coal mining experience in England before he came to South Africa :—

In Mr. Dewar's paper, the first accident reported was that at Brakpan on the 19th March, 1913. I was at Brakpan at that time, and just after the accident was transferred to that section as shift boss. The winze was then being allowed to overflow into the drain on the drive, and carbon came with the water in such quantities as to cover the bottom of the drain. I concluded that CH_4 brought down in bubbles which burst as the water left the fault had caused the accident.

The first signs of CH_4 on the Rand that I know of were found in the Rand Collieries Gold Mine, early in 1910. I was with the manager, and we came to the foot of a rise going up at 15° for 200 ft. It ended at a fault and water came from the hanging for about 10 ft. from the fault. I had not been in that rise, and, at the manager's request, started to go up. When I was up about 10 ft. my acetylene light went out suddenly. I thought that I had jerked it, and turned and got it relighted. At the same place the

light again went out after I had seen a blue flash of flame. I told the manager that it was either CO from blasting or CH_4 coming down with water through a fault from the coal measures. Some weeks after, it was decided to clear the rise so as to make a connection to the level above. I told the pipe fitters to connect the air to the pipes which they had pushed up and to keep on the intake side while the air was blowing. About an hour later I returned to find out whether the place was safe for further work, and walked up a connecting rise with my candle low, to a drive running off the rise. Thinking all was clear, I lifted my candle, and the next second was in a raging flame, and I dropped and rolled down the rise, being severely burned and otherwise injured.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Methyl Orange as Indicator.—"Chlorine in either acid or alkaline solution destroys methyl orange and bromine acts similarly, whereas iodine is without effect. Hydrosulphurous acid destroys methyl orange, but not in presence of formaldehyde; the destruction caused by certain alkali sulphides depends on the presence of accidental impurities. Of oxygen-yielding compounds, hydrogen peroxide is without action on methyl orange, but ozone readily destroys it. In the alkali metric titration of percarbonate the indicator is destroyed immediately any free alkali carbonate is completely neutralised and the percarbonate begins to undergo decomposition. The indicator is readily destroyed by nitrous acid but serves in titrating cyanic, thiocyanic, and carbonylferrocyanic acids; with hydrocyanic acid it is insensitive and with ferrocyanic acid uncertain. Certain bases, notably ferrous and manganous oxides, destroy it, the yellow colour persisting when a solution of a ferrous or manganous salt, precipitated by addition of alkali, is re-acidified. This phenomenon, due to the reducing action of the two hydroxides, is not observed if hydrogen peroxide is added prior to the alkali. Both the free and the combined acid in solutions of ferrous and manganous salts may hence be determined by titration. With ferrous salts it is necessary to allow for the free acid entering into combination in accordance with the equation: $2FeSO_4 + nH_2SO_4 + O = Fe_2(SO_4)_3 + (n-1)H_2SO_4 + H_2O$; with manganous salts, however, manganic salts are not formed under ordinary conditions. Stannous chloride also destroys the indicator, but only in acid solution, and here, too, when hydrogen peroxide is used, the free acid combining to form the stannic salt must be taken into account. Copper salts behave like those of tin, and cobalt salts like those of iron and manganese. The mercurous oxide precipitated from the nitrate by addition of alkali does not destroy the coloration but carries down the colouring matter with it. In the titration of commercial and fuming sulphuric acid methyl orange is sometimes destroyed owing to the impurities present, and the same is observed with alkali hydroxides, even with those sold as pure. Ethyl alcohol is markedly alkaline towards methyl orange, whereas methyl alcohol is without effect."—V. Macri, *Boll. Chim. Farm.*, 1920, *59*, 193—196. —*Journ. Soc. Chem. Ind.*, Sept. 15, 1920, p. 611A. (J. A. W.)

Preparation of Methyl Red.—"A mixture of anthranilic acid, 137, water, 1000, crushed ice, 300 g., and hydrochloric acid (sp. gr. 1·18), 222 cc., is stirred and kept below 5° C., while a mixture of sodium nitrite, 59, and water, 150 g., is added. The whole is stirred for a further 20 min., and then added to a mixture of dimethylaniline, 121, water, 200 g., and hydrochloric acid (sp. gr. 1·15), 90 cc. After a few mins., a mixture of fused sodium acetate, 165, and water, 500 g., is added. The purple red crystals which separate when the mixture is set aside for some hours are collected, washed with cold water, dried at 50° C., and recrystallised from alcohol. The yield of the crude product is about 43% of the theoretical amount calculated on the anthranilic acid."—L. Desvergnes, *Ann. Chim. Analyt.*, 1920, *2*, 209—210.—*Journ. Soc. Chem. Ind.*, Sept. 15, 1920, p. 611A. (J. A. W.)

Rapid Method for Determination of Arsenic in Sulphuric Acid.—"To determine arsenious acid, 20 g. of acid is diluted with water, and methyl orange added. To the solution is added a saturated solution of sodium carbonate until only a very faint pink colour persists, after which 2 g. of powdered sodium bicarbonate is added. The solution is diluted to 250 cc. with water and titrated with $N/10$ iodine and starch, a blank titration being made. For the estimation of quinquevalent arsenic 20 g. of acid is heated at 105°—110° C. for 1 hr., diluted with a small amount of water, and saturated sodium carbonate added in slight excess, phenolphthalein being used as indicator. The solution is boiled and filtered. To the filtrate are added 3 g. of powdered sodium bicarbonate, 150 cc. of concentrated hydrochloric acid slowly with agitation, and 1 g. of potassium iodide, air being excluded. After agitation and standing for 5 mins. the liberated iodine is titrated with $N/10$ thiosulphate and starch. Copper salts interfere with the determination, but are usually negligible. If present in quantity, the amount of potassium iodide should be increased."—A. A. Kohr, *J. Ind. Eng. Chem.*, 1920, *12*, 580—581.—*Journ. Soc. Chem. Ind.*, July 31, 1920, p. 511A. (J. A. W.)

Determination of the Yield of Tar from Coal.—"The apparatus consists of an aluminium retort, the interior walls of which slope towards the base to facilitate removal of residue, and having a close-fitting lid. On one side of the retort is a nose-shaped extension with central bore, into which is screwed a brass tube through which the tar distils into a glass receiver immersed in water. A thermometer is inserted into a semi-circular expansion

of the retort wall. For the estimation 20 g. of coal is heated to 500°—520° C. within 30 mins., the temperature being maintained for a further 15 mins. The distillate is then weighed, after which the water constituent is distilled off with xylol or centrifuged, the residual tar being again weighed. Results obtained with several varieties of coal are tabulated."—F. Fischer and H. Schrader, *Z. angew. Chem.*, 1920, *33*, 172—174.—*Journ. Soc. Chem. Ind.*, Aug. 31, 1920, p. 566A. (J. A. W.)

METALLURGY.

Liquid Air Blasting.—M. Grabianowski, a Polish engineer, who, owing to his official position in the Upper Silesian Mining and Smelting Society at Kattowitz, has had exceptional opportunities to study the records relating to accidents due to the use of liquid air for blasting, has lately published the results of his research in the *Czasopismo Gornicze Hutnicze* (*Mining and Smelting Journal*) of Cracow, from which the following conclusions are taken :—

(1) Liquid air cartridges are infinitely more dangerous than is black powder.

(2) Such air cartridges, if carefully handled, are of great service in metalliferous mines, provided they are exploded by electricity with powerful detonators and the shot firer carries a miner's safety lamp.

(3) In wet coal mines where there is no dust or fire damp, the use of liquid air cartridges, though not recommended, is possible under great precautions. The tamping should be done with clay, powerful detonators should be used and fired by electricity, as in the former case, and the shot firer should carry a miner's safety lamp. The floor should be well watered in front of the shot-holes, and great care should be taken not to spill any liquid air on the floor, as the liquid air mingling with the coal dust turns this into an explosive. Only one shot should be fired at a time, for reasons set out below.

(4) In dusty or fiery coal mines the use of liquid air is extremely dangerous, and should be absolutely prohibited.

(5) Nearly empty containers of liquid air or dipping vessels are liable to explode, especially if the heat-insulating sawdust between the inner and outer vessels is not absolutely pure, and is not absolutely free from chlorate of iron found in some timbers. The liquid air evaporates and finds its way to the impure sawdust, which becomes heated and explodes owing to the presence of the chlorate of iron. All vessels should be kept scrupulously clean, as any coal dust accumulated on them is a source of danger.

(6) Liquid air cartridges explode with a very long flame: those filled with soot producing a flame about $4\frac{1}{4}$ ft. long, those filled with sawdust a flame about $7\frac{1}{2}$ ft. long.

(7) Insufficiently impregnated cartridges are liable to miss fire at first, but have been known to explode as much as an hour afterwards. Moreover, they are liable to produce carbon monoxide in dangerous quantities.

(8) When several holes are fired simultaneously and one of the cartridges lags behind, it is liable to explode the coal dust created by preceding shots.

(9) Liquid air cartridges had been a useful substitute for other kinds of explosives during the war when there was a shortage of such other more reliable kinds of explosives, but their use should now be stopped, except in cases of necessity, in coal mines. As a matter of fact, in Poland their use was discontinued from the moment that other supplies of explosives, even of second-rate quality, again became available.

According to Mr. George S. Rice, of the U.S. Bureau of Mines, all early attempts to use oxygen as an explosive were erratic, for it was not known that a high concentration of oxygen was required. Since the Armistice, the Bureau of Mines has found by experiment that from 90% to 95% oxygen and 10% to 15% nitrogen give best results.

After the Armistice, a commission sent by the U.S. Secretary of the Interior to study the progress made in the use of liquid oxygen explosives found that the Allies had done little in this direction. At Nancy and Briey, they saw the effects of the use of this explosive by the Germans. They used a system of mining similar to that used for a thick seamed coal bed. Two men worked in a face, each one carrying a container containing five litres of liquid oxygen. The containers consist of a double-walled spherical vessel of thin brass, with a thin evacuated space between. They have a cup containing charcoal at the bottom to absorb air and assist in maintaining the vacuum. The container has a long stem, and is placed inside a large galvanised vessel for carrying. The miners are also provided with a dipping vessel. The sawdust or wood pulp cartridge, made in the ordinary size, is dipped into this container after oxygen has been poured into it. After the holes are drilled, a fuse is put in and the dipped cartridge inserted in the usual manner. The time element is an important one, because that is the weakness of liquid oxygen explosives; they must be used within five minutes after the oxygen is poured for the shots to do their work properly.

In the Saar district, the Germans tried, but were unsuccessful, to use liquid oxygen explosives in gaseous coal mines; they did, however, use a liquid oxygen detonator. It is difficult to get accurate figures as to cost. From German literature, some mines, in 1915 and 1916, were getting the explosive at an equivalent in dynamite of from 11 to 13 cents ($5\frac{1}{2}$d. to $6\frac{1}{2}$d.), a pound, including all costs, overhead and depreciation. The plants cost from $10,000 to $20,000.

The French think that liquid oxygen has come to stay, provided the Government does not tax the makers out of existence. The explosive, however, has serious limitations. It cannot be used in gaseous coal mines, because one cannot always get a perfect mixture. It can be used in non-gaseous coal mines, yet it cannot be said what the percentage of oxygen will be at the moment of explosion. There can be no danger of misfires, if only a single shot is fired, for after fifteen minutes there is no explosive left. It cannot be used in a place where a large number of shots must be fired at the same time, for the time of loading would be so great that the oxygen would lose its strength. It can be used to advantage in quarries where single shots are fired.—*Iron and Coal Trades' Review*. (J. C.)

Abstract of Patent Applications.

1191/20. R. D. Boyce. An improved device for jointing a tube made of elastic material to a rigid pipe. 1.11.20.

This application refers to an appliance for readily jointing a tube or hose made of elastic material to a plain rigid pipe of smaller diameter, and particularly for enabling liquid tight connections to be made in the water, oil, and fuel systems of internal combustion engines.

The appliance consists of a tubular thimble (preferably made of metal) having a frusto-conical screw threaded bore adapted to pass over the rigid pipe, the larger and smaller ends of the thimble having internal diameters respectively greater and less than the external diameter of the elastic tube, whilst the smaller end of the thimble has an internal diameter too small to admit the elastic tube between it and the rigid pipe, so that the thimble is adapted when rotated in the proper direction to screw over over the elastic tube and by compressing it against the exterior of the rigid pipe, to bind the two together with a fractional force, sufficient to resist any tendency to separate them by movement in the direction of their common axis.

1196.20. J. J. Collins. Improvements relating to the purification of tin or the production of tin salts from crude tin. 1.11.20.

The purpose of this application is for the purification of tin metal which is associated with impurities such as bismuth, antimony, lead, iron, etc., by subjecting the tin in a fine state of division to the action of stannic chloride, thereby producing stannous chloride. The stannous chloride is withdrawn from the re-action vessel and allowed to cool. The tin may be recovered from the stannous chloride by electrolysis or replacement by zinc.

1220.20. Holman Bros. Improvements in or relating to rock drills. 5.11.20.

This application refers to rock drills of the hammer type, and states that it has for its object the provision of an improved manner of moving the drill tool about its axis during the cutting operation.

Hitherto it has been customary with rock drills to rotate the drill tool about its axis in one direction only during the cutting operation, and this has been effected in some cases by means of an oscillating piston device from which intermittent motion was imparted to the drill tool to rotate it about its axis always in the same direction.

According to this application the drill tool during drilling is oscillated about its axis in alternate directions as distinct from rotating it about its axis always in the same direction.

In one form the device consists of a fluid operated piston arranged to oscillate transversely of the axis of the chuck, to which it is operatively connected, so as to impart oscillatory motion to the latter during drilling.

In another form the device is applied to hammer drills of the air feed type, in which the air feed cylinder is held stationary either in a clamp or an arm or bar, or by an anchor engaging any convenient surface, as, for instance, a flank or a stull piece. The plunger carrying the machine is oscillated relatively to the air feed cylinder by a fluid operated piston suitably arranged transversely to its axis.

1239.20. J. J. Collins. Improvements relating to the winning of tin. 11.11.20.

This application is for a process for extraction of tin from tin ores or tailings by treating the ore to a reducing gas at suitable temperature to convert the oxide to metal, and subsequently subjecting the ore to the action of dry chlorine gas, whereby stannic chloride which is liquid at ordinary temperature is produced.

The tin may be recovered from the chloride by passing over zinc scrap or shavings, producing spongy tin and zinc chloride.

1326.20. C. R. Burton. Improvements in or relating to the construction of walls for houses and other structures. 3.12.20.

This application refers to the construction of walls for houses and similar buildings, and states that its particular object is to facilitate the rapid erection of houses, especially those of small or medium size, in a simple and economical manner.

The application describes a purpose moulded concrete block of specific form which is laid in a specific manner. Methods of forming openings in walls built of these blocks are described.

The faces of blocks may be plain or ornamented.

1347.20. S. Fisher. Improvements in spring feed arrangements for rock drills. 9.12.20.

This application refers to feed arrangements for hammer rock drills of the kind described in the specification of patent No. 223 of 1919, in which a carrier for the machine slides in a cradle and is pressed forward thereon by a spring which is itself movable along the cradle and engages rack teeth on the latter to exert feeding pressure therefrom.

In the present form a rock drill of the hammer type is mounted on a carriage which slides on a T iron guide or cradle. Rack teeth are formed on the latter which engage with a so-called "anchor plate." A helical spring surrounding the T iron guide, abuts between the front of the carriage and the anchor plate.

A lever is provided by means of which the anchor plate is thrust forward compressing the spring a few inches at a time, and retained by engagement with the teeth of the rack. The pressure of the compressed spring against the front of the carriage provides the necessary feeding force for drilling.

1348.20. English Electric Co., Limited. Improvements in or relating to governing water wheels. 9.12.20.

This application refers to the governing of water wheels by varying the pressure of the water jet issuing from the nozzle.

The main features are: the arrangement within the nozzle of movable guide vanes, which may be moved in such a way as to allow of the jet leaving the nozzle in a solid or split up form.

The size of the jet may be varied by the movement of a needle arranged axially within the nozzle. The whole is controlled with a centrifugal governor by suitable transmission gears, fluid relays, cataract and so on.

THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA.

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Proceedings

AT

Ordinary General Meeting, 21st May, 1921.

The Ordinary General Meeting of the Society was held in the Assembly Hall, Scientific and Technical Club, 100, Fox Street, Johannesburg, on Saturday, the 21st May, 1921, at 8 p.m., Prof. G. A. Watermeyer (Vice-President) in the chair. There were also present:—

23 Members: Messrs. F. Wartenweiler, F. W. Watson, C. J. Gray, J. Hayward Johnson, Andrew King, Dr. A. J. Orenstein, John Watson, A. Whitby, H. A. White, J. A. Woodburn, Dr. W. A. Caldecott, Jas. Gray, E. H. Johnson (Members of Council), T. N. Dewar, H. L. V. Durell, E. C. Homersham, K. Leinberger, W. C. Lindemann, C. A. Meiklejohn, H. A. Reid, W. E. Thorpe, Jas. West and H. R. S. Wilkes.

1 Associate: O. A. Gerber.

16 visitors and H. A. G. Jeffreys (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 16th April, 1921, as recorded in the April *Journal*, were confirmed.

NEW MEMBERS.

A ballot was taken for the election of new members, and the following were declared unanimously elected:—

Rose Innes, Alexander, Aurora West G.M. Co., Ltd., P.O. Box 26, Maraisburg: Mine Manager.

Webber, Henry O'Kelly, c/o National Bank of S.A., Ltd., Simmonds Street, Johannesburg: Director of Companies.

West, James, P.O. Box 1253, Johannesburg: Mine Manager.

SCRUTINEERS FOR BALLOT AT ANNUAL MEETING.

The following gentlemen were appointed scrutineers for the ballot at the annual meeting in June next:—Messrs. C. A. Meiklejohn, A. Thomas, S. Newton and P. J. Morrisby.

General Business.

AWARD OF SAFETY FIRST MEDALS.

The Chairman: The next business is the presentation of Safety First medals. The Safety First Competition in connection with the recent Chemical, Metallurgical and Mining Exhibition was organised by the Society, while the medals have been presented by the Rand Mutual Assurance Co., Ltd.: the judges were: Sir Robert Kotzé, our President (Mr. J. Chilton), Mr. J. A. Woodburn, and Mr. F. G. A. Roberts. The silver medal has been awarded to Mr. S. B. N. Hill, of Breyten for a fuse and detonator holder. The bronze medal has been won by Mr. James P. Young with a clamp for mill stems.

ANALYSIS OF FAR EAST RAND ORE.

Mr. F. W. Watson: Analyses have recently been carried out on samples of ore from a mine in the Far East Rand district, and are of interest in that this material shows characteristics differing from ores in the Central and Benoni districts. The analyses were carried out in the Rand Mines Laboratory by Mr. R. A. Cooper.

Sample I. is a composite sample from developed ore in the mine; II. is a mill screen sample from the same mine, and, in addition to the usual run of mine ore, contains a portion of partially weathered ore from a mine dump. III. is an analysis by Mr. A. McA. Johnston taken from Rand Metallurgical Practice, Vol. I., Chapter XI., of Knights Deep ore, and is quoted for com-

parison as representing the better known class of banket ore :—

	I.	II.	III.
	%	%	%
Insoluble in aqua regia ...	95·75	93·80	
Pyrite (FeS_2)	1·65	1·91	
Pyrrhotite (Fe_7S_8) ..	0·13	Trace	
Metallic iron (Fe) ...	—	0·028	
Ferrous oxide (FeO) ..	0·83	0·91	
Ferric oxide (Fe_2O_3) ...	—	0·31	
Alumina (Al_2O_3) ...	0·60	1·21	
Arsenic sulphide (As_2S_3) ...	0·08	0·02	
Nickel sulphide (NiS) ...	0 336	0·036	
Cuprous sulphide (Cu_2S) ...	—	0·012	
Lime	0·05	0·44	
Magnesia	0·08	0·37	
Soluble silica	0·20	0·23	
Combined water	—	0·62	
Silica (SiO_2)	—	—	86·76
Pyrite (FeS_2)	—	—	2·75
Ferric oxide (Fe_2O_3) ..	—	—	2·65
Alumina (Al_2O_3)	—	—	6·91
Lime (CaO)	—	—	Trace
Magnesia (MgO) ...	—	—	0·70

In I. and II. the portion insoluble in aqua regia contains a fair proportion of silicate of alumina, which would account for the marked difference found between these two and III., which has probably been fused.

The presence of arsenic sulphide which is of interest, was further confirmed in a concentrated sample in which the mineral orpiment was identified and separated. Assay of this separated mineral does not disclose any association with gold. On agitating the slime from this ore with caustic soda arsenic is found in solution.

Zinc blende and galena are sometimes found in hand specimens, but were not detected in the analyses.

Vanadium and metals of the platinum group are present in minute quantities.

With regard to the method of analysis; metallic iron was determined by deposition of copper from a solution, while ferrous oxide was estimated by rapid treatment with HCl in an atmosphere of CO_2 and immediate titration with bichromate.

The arsenic present was insoluble in nitric acid, as would be expected.

In I. the iron oxide is all given as ferrous, the H_2S evolved by the pyrrhotite would prevent separation of the ferrous and ferric iron being effected. In II. the ferric iron figure is probably low owing to the reducing action of the small quantities of metallic iron and nickel sulphide.

NOTES ON SOME TECHNICAL METHODS OF ANALYSIS.

By A. Whitby and J. P. Beardwood.

In offering these few notes on points observed in the course of ordinary laboratory work, we do not claim finality, nor do we invite destructive criticism. It must be understood that a public chemist has little time for research, and any experimental work must be dovetailed in with the day's routine.

Of course, we all know Low's "Technical Methods," and we, personally, have always upheld it as a standard work, but on a few points it has failed us.

As a first example, Low deals with the assay of nickel and cobalt ores, in our opinion, on wrong lines. He overlooks or ignores the common association of these metals with arsenic and iron. His procedure is to take down with nitric acid and chlorate and add ammonia to dissolve out the nickel and cobalt. We have found, however, that an arsenate of iron tends to dissolve in the ammonia (see ferric arsenates in Comey's "Dictionary of Solubilities," p. 35). It is somewhat surprising that Low never gave attention to this point, so materially interfering with the subsequent conduct of the assay.

Arsenic must be removed, and the best results are obtained by aqua regia treatment, followed by citric or tartaric acid, sodium hydroxide and sodium sulphide. After digestion, the insoluble sulphides can be filtered off and treated by ordinary methods, the arsenic being in the filtrate. Methods of analysis become more intricate in the case of some complex ores which have come to us, containing leucopyrite, monazite, and molybdenite, as well as cobalt and nickel, but any description of the methods of separation adopted in these cases passes beyond the limit of this note.

Arsenic, by the way, can be easily and quickly determined by the method given for phosphorus in rocks (provided, of course, that phosphorus is absent) in our *Journal*, December, 1917, p. 156.

Another point arises in the determination of chromium in chromite. According to Low, the filtrate after fusion in a nickel crucible with sodium peroxide and the usual treatment is apparently free from chromium. We have found this to be incorrect, on account of certain reducing actions which tend to retain chromium in the precipitated

hydrates. Evidently Dr. Moir has sensed the difficulty. (*Vide Journal of S.A. Association of Analytical Chemists*, January, 1919.)

The main point is, are these reducing actions due to carbonaceous matter or nickel set free from the crucible? On 50% Cr_2O_3 ores we have noted differences against other chemists of 2% to 4%. Dr. Moir says they may rise to 10%, and he is doubtless not far wrong on the 100% basis.

This difficulty in the application of the process described by Low may be overcome by adding successive washes of hot sodium peroxide solution to the filter. The effervescence of oxygen tends to break up the insoluble matter and oxidise any chromyl salts present. These washes are best boiled by themselves and are then added to the main filtrate. We must confess to a predilection for the use of ferrous ammonium sulphate and standard bichromate instead of permanganate, in spite of Dr. Moir's claim for the latter. Moreover, bichromate is stable and permanganate is not.

One other point occurs to us that Low now uses 4·74 grms. of ammonium molybdate for making up his standard in the Alexander method of determining lead. His earlier editions say 8·5 grms. per litre. The commercial salt has the composition $(NH_4)_6Mo_7O_{24}.4H_2O$ and with 8·5 grms to the litre gives the factor ·00996 grm. per cc. The quantity used by him in making his present solution, which is half the strength formerly used, should be somewhere a trifle above 4·25, but nowhere near 4·74 grm.

NOTES ON SOME REACTIONS OF THE XANTHATES.

By A. Whitby and J. P. Beardwood.

Some of you may not be acquainted with Xanthates, and a little explanation may not be out of place. They are salts of ethyl-$\alpha\beta$ dithiocarbonic acid, otherwise known as xanthic acid.

In an abstract appearing in our *Journal*, October, 1920, p. 65, reference is made to the delicacy of the reaction between alkaline xanthates and molybdenum in solution. Either the potassium or sodium xanthate is easily prepared by dissolving the hydrates in the least possible quantity of alcohol and adding carbon bisulphide to neutrality. After some time crystals separate which can be filtered off, washed with ether and dried over sulphuric acid.

It is well known that the soluble salts of this acid—let us limit them for the present to those of the bases potash and soda—form precipitates with most of the heavy metals, and the idea struck us that this might be utilised in certain separations, particularly in regard to the determination of nickel, cobalt and copper. The xanthates of these metals are precipitated from ammoniacal solution by acetic acid. Nickel is entirely dissolved by ammonia.

The process adopted for the separation of these metals from empirical mixtures is as follows:—

Nickel and Cobalt.—To the solution add about 1 grm. of citric acid and render ammoniacal. Add potassium or sodium xanthate about 1 grm. and acetic acid to precipitate the xanthates. Allow to stand two or three hours warm, but not boiling. Filter wash with warm water. Transfer precipitate to original beaker and treat with ammonia (50% of ·880), warm on water bath, filter and wash with ammonia as above till the filter shows no trace of yellow colour. The nickel will now be all in the filtrate, the cobalt remaining on the filter.

The nickel can be precipitated by acidification with acetic acid, filtered and washed. Both precipitates are ignited at a full red heat in the muffle. Copper, when present, is not dissolved by ammonia like nickel, but remains with the cobalt and can after the ignition be dissolved in hydrochloric acid and removed by sulphuretted hydrogen.

It may be remarked that cobalt compounds, such as the sulphide and xanthate, cannot be converted completely into Co_3O_4 unless ignited in a muffle with free access of air and at a fairly high temperature.

Some examples on prepared solutions are here given: all quantities are equal, and all are shown as their oxides:—

Cobalt precipitated by caustic soda ...	0·0677 grm.
Nickel precipitated by caustic soda	0·1072 ..
Cobalt precipitated by xanthate	0·0677 ..
Nickel precipitated by xanthate	0·108 ..

Separations.

Cobalt from nickel—

Cobalt	0·067	Nickel	0·106
..	0·075	..	0·098
..	0·065	..	0·108

Copper was recovered in mixtures of the three elements: Called for 0·125 grm.; by xanthate 0·127. In the presence of nickel and cobalt, results were recorded of 0·127, 0·129 and 0·1255 grm.

An outline of a method for separating these metals in the presence of iron and arsenic in ores may be given here. Dissolve 1 to 5 grms. of the ore in aqua regia, add 3 grm. of citric acid, filter, wash, render ammoniacal, add 1 to 2 grm. xanthate and then acetic acid as above. Filter and wash, when most of the iron and arsenic will be in the filtrate. On removing the nickel with ammonia as before, any remaining arsenate is carried through and remains in solution after the acetic acid is added to precipitate the nickel. The practical application of the xanthates to analysis is by no means exhausted. Investigation may yet show that they can be applied to the separation of the heavier elements.

The Chairman: Messrs. Whitby and Beardwood deserve the thanks of the Society for their very able papers. Records of original observations are never superfluous: and I am sure we are always very grateful to receive them. They need not fear any destructive criticism from me, because I shall leave it to those more expert in chemistry.

Mr. F. W. Watson: I have much pleasure in seconding the vote of thanks to Messrs. Whitby and Bearwood for their paper. The solubility of ferric arsenate in ammoniacal solution strikes me as being rather surprising.

With regard to chrome iron ore I do not think it is necessary to filter the alkaline solution after fusion; it can be acidified and then oxidised with permanganate at boiling point, as usual. Dissolved nickel and iron have no effect on the determination.

SYMPOSIUM: MINERS' PHTHISIS

CINEMA FILM, "THE DUST THAT KILLS."

This film, prepared by the African Films Trust, Ltd., for the Transvaal Chamber of Mines, was then screened, and greatly appreciated by those present.

Mr. H. J. Ireland (Testing and Investigating Engineer, H.M. Office of Works, London): I wish to deal with two methods of amelioration, viz., the dilution of dust by ventilation, and the provision of conditions tending to raise immunity from disease.

We want, if possible, to have a current of air sweeping the working faces at a velocity of 1 to 2 metres per second (about 200 ft. to 400 ft. per minute); the main supply for the mine, split up among the various working sections will be, of course, quite inadequate to effect this; but I can see no reason why each section should not have a local circulation of its own, with its share of the main fresh air current entering at one point, and an equal amount of air vitiated by heat, dust, and perhaps poisonous gases, leaving it at another point to join the return. Let me illustrate by a simple example which makes no pretensions of giving actual figures in practice. Assume a mine or section of a mine served by a shaft through which we can introduce 100,000 cubic feet of fresh air per minute; this main current has to serve ten sections, each getting 10,000 cubic feet of air, but in each section we circulate another 50,000 cubic feet, making altogether 60,000 cubic feet flowing through the workings of each section, 10,000 cubic feet of fresh air coming in from the main supply and 10,000 cubic feet of more or less vitiated air going out to the main return. There should be no difficulty about means of effecting this type of circulation; it has been done frequently on a small scale in other lines, such as drying plant, and is largely a matter of the necessary fans and regulating doors. Then we have to employ means of getting the air currents to follow the stope faces; such means might be "closing the passage through the centre of the stope" as suggested by Mr. C. J. Gray, or closing up the air passages except those in line with the working faces, or building short directing walls of waste rock inside the stope, or even by means of small portable fans to boost and concentrate the air current where it tends to diverge from the face. I have heard widely differing expressions of opinion on the practicability of this proposal. Some mine officials whose opinion is certainly worthy of respect, tell me it is quite impracticable, while others who are perfectly familiar with all the conditions of underground working say there is no reason why it cannot be done. I am not sufficiently familiar with underground conditions to give a dogmatic opinion, but I cannot help feeling that there is too much tendency to turn down a proposition as impracticable, because it holds out the promise of only partial success, or because it cannot be applied to every case. If by "the simultaneous application of a number of measures, each of but low efficiency" it is possible to achieve some improvement along the lines indicated, it will be well worth trying.

It may be that the dust content in the air circulating in each section may reach eventually a dangerous concentration, the supply of fresh air from the main supply not being sufficient to give adequate dilution, in which eventuality a dust-catcher is called for. Although it is a difficult problem to catch fine dust, the difficulty should not be insuperable. From my experience of cyclone or centrifugal dust traps as used for vacuum cleaning or dust exhausting in industrial processes and grain elevators, I am certain this type would be hopeless for our purpose; the palpable dust would be thrown out and separated, but the very fine dust, which is so deadly, would get through and escape. Neither am I very hopeful of catching the dust by washing the air with water sprays. It is amazingly difficult to get very fine dust particles wetted with even a very fine dense spray. With a view to getting a satisfactory means of eliminating dust, smoke and fog from London air for ventilating public buildings, I have made several tests on installations of air washing plant, in which the air is forced through a chamber filled with very fine dense water spray, and none of them will eliminate smoke; dense black smoke from oily waste comes out pretty much as it goes in. I have more faith in some method using condensation of moisture from a saturated atmosphere assisted perhaps by an electrical discharge to assist formation of mist, the moisture particles and contained dust being caught by baffle or eliminator plates as used in some types of air washer. A still better method, in my opinion, would be the use of plant precipitating dust on to wet or dry metal plates by an electrical brush discharge, the great advantage of this method being that it deals effectively with the finest of dust. Apparatus of this type is already in use in America for eliminating dust nuisance from various industrial processes, and just at the outbreak of war an English firm was developing this principle for the recovery of more or less valuable metallic fumes; moreover, just before I left England, about two years ago, another English firm was experimenting very successfully with an air washer in which dust, fog, etc., were precipitated by electrical discharge on to louvre vanes over which a continuous stream of water was flowing. I mention these to show that these methods are already "practical politics" and not merely wild ideas of a theorist. In connection with dust depositors of this class, I should mention that a considerable quantity of ozone is produced which may be beneficial, and will give the air a fresh pungent odour which is quite stimulating, but that, on the other hand, some nitrous oxide (N_2O) will be formed which is not beneficial, especially if formed in excess, which is the case when the electrical discharge is too intense.

The increased ventilation to dilute and carry off dusty air will incidentally give the atmosphere greater cooling power and make it refreshing and wholesome to work in. This brings me to my second point, viz., atmospheric conditions to improve immunity to disease.

I think we can take it as an established fact that an atmosphere which produces a large evaporation from the respiratory tract, induces a correspondingly great immunity from respiratory disease. Dr. Leonard Hill attributes this to the increased flow of immunising fluids from the lymphatic glands to the mucous membrane. In any case it is common knowledge that men affected with miners' phthisis who may be maintaining weight and a fair degree of health in a dry climate like that of the Rand, frequently go to pieces very quickly if they move to a humid climate like that of Durban or Cornwall. There is little doubt that the very humid atmosphere of the mines tends to lower the immunity for the time being from respiratory diseases, and this is aggravated by the strain of working in places where the "cooling power" of the air is utterly inadequate. I have been wondering for some time whether evaporation from the respiratory tract has any influence on silicosis, whether a large evaporation would tend to prevent the dust block in the lymph glands that Dr. Mavrogordato has been telling us about; perhaps he can enlighten us.

So far as humidity is concerned, it would appear that we are on the horns of a dilemma. We apply water to keep down deadly dust, but the prevalence of wet surfaces, water sprays, etc., makes the atmosphere intensely humid and to that extent unwholesome. By reducing the temperature of the atmosphere, however, we can lower the absolute humidity without the necessity of keeping all surfaces dry, and the consequent risk of dust. Mr. E. H. Clifford, in his paper on the new scheme for the City Deep mine* has shown that in a new mine at least, this is quite within the capacity of modern ventilating practice, and that the temperature can be lowered considerably by taking sufficient dry cool air down the mine. There

* Journal of S.A. Inst. of Engineers, March, 1921.

are probably some mines where the air intake is already limited by the capacity of the shaft, but there must be many mines where some improvement in this respect could be effected. In dealing with humidity we should bear in mind, that so far as the human organism is concerned it is absolute humidity—actual moisture content—not relative humidity which matters. It is difficult to get people to realise this. Air at 40° F. though saturated (100% relative humidity), will contain much less moisture than air at 80° F. with a relative humidity of 50%. On a cool dry winter day on the Rand with temperature at 45° F. and relative humidity 20%, the evaporation from the respiratory tract per 100 cubic feet of air breathed is approximately 0·21 lb.; in a good place underground with temperature 65° F. relative humidity 90%, the corresponding evaporation is 0·16 lb.; and in a hot place with 87° F. and 95% humidity, 0·063 lb., or a little over a quarter of the first. Here, again, there should be "something to aim at," especially as the dry atmosphere of the Rand gives us a good margin to work with, and I suggest 0·16 lb. per 100 cubic feet, *i.e.*, a dew-point of 60° F. (approx.).

Perhaps better ventilation might be so effective in dealing with dust, that the necessity for so much water may be eliminated and we might find it possible not only to keep the temperature low, but to get a humidity considerably below saturation. The facts given by Mr. D. Harrington, of the U.S.A. Bureau of Mines, seem to point to the effectiveness of good ventilation in preventing miners' phthisis, even in mines where no wetting down is practised.*

At any rate, there is a good field here for intelligent experiment, and I think it is along such lines as these that the most fruitful results will be obtained. In this connection there is to be considered "the dry shaft and dry airways" method advocated by Mr. E. H. Clifford, the air being kept from absorbing much moisture until it approaches the working places, where it is cooled by water sprays. This will give the advantage of less extremes in "cooling power," reducing the "cooling power" in the main ways and waiting places, where it is usually excessive, and increasing it in the working places where it is usually inadequate.

No one, so far, has mentioned the Kata-thermometer, so I would like to put in a plea for the extensive use of that instrument as a means of improving the cooling power of the air in the working places. Kata readings of the various working places might to advantage be marked on the quarterly ventilation plan and the general condition of the mine in this respect could be ascertained by a few minutes' inspection of the plan, improvement or retrogression being noted.

I think the idea of supplying small quantities of ozone to the atmosphere is worthy of consideration, as it seems to have the effect of stimulating resistance to bacterial invasion. To be effective it should be supplied as near the working places as possible. If ultra-violet light is used as the ozonising agent very little of the deleterious nitrous oxide is formed and the light itself is a powerful bactericide.

These are some of the many directions along which experiments might be carried out, and if the combined efforts of scientists and men of practical experience are applied to the problem, no doubt something worth while will be achieved. Indeed, there are already so many principles established by research of physiologists and others, that they only await the engineer finding means of effecting them.

Some years ago, I remember A. H. Barker, an engineer who has applied a great deal of science to the problems of heating and ventilating, in a lecture at University College, London, challenged the physiologists to state their case on ventilation. "Tell us," he said "what is wanted, and we engineers will give it." The physiologists in recent years have told us very definitely what is wanted, and one feels it is now "up to" the engineers "to deliver the goods."

Mr. H. C. F. Bell: At the last meeting of this Society I expressed my opinion that one of the chief sources of miners' phthisis is the blowing out of machine holes, particularly in development. This evil can be partly overcome by blowing out with a mixture of air and water. This is done by attaching an air hose to the water-blast, turning the water full on, then turning on the air, and as soon as the mud is out of the hole, the water can be shut off. The air then clears the hole of water. For this purpose the water blast should be made with an inch T piece, so that an air spud can be fitted into it.

*See paper on "Metal Mine Ventilation" to the Lake Superior Prevention of Accidents Conference; abridged in *Safety Engineering* August, 1920.

THE KATA-THERMOMETER AND ITS PRACTICAL USE IN MINING.

By H. J. Ireland, M.B.E., B.Sc., A.M.I.C.E.

(*Printed in Journal, November, 1920.*)

REPLY TO DISCUSSION.

I have to thank the Society for the kind reception given to my little paper and for the interest shown in the subject. I would like to have seen more discussion, as the subject of atmospheric cooling power is bristling with points both of theoretical and practical interest.

Before dealing with pionts raised, I should like to make some modification of a statement I made. I said that due to convection of heat from the rock it would be difficult, if not impossible, to increase considerably the cooling power in the workings from the factor of temperature. At that time I had not gone into the question of the conductivity of the rock and the amount of heat emitted therefrom, and accepted the prevalent view that the heat capable of being emitted was well-nigh infinite and that the air temperature would therefore follow more or less closely the rock temperature. Soon afterwards Mr. E. H. Clifford showed me his schemes for the new City Deep shaft, and demonstrated to me, with the help of conductivity tests and calculations by Professor Lehfeldt, that the heat emitted was by no means infinite, and that it was quite within the capacity of the ordinary means of ventilation to reduce the average underground air temperature considerably. In the case of the City Deep he calculated on a reduction to an average temperature of 22° C. (71·6° F.). This reduction of temperature is, of course, all to the good, as it not only makes a high cooling power possible with a small air velocity, and a tolerable cooling value even in still air, but it reduces the absolute moisture content in the air and thereby gives an increased evaporation from the respiratory tracts of the workers, which is, in my opinion, a factor of considerable importance in combating miners' phthisis.

There will always be some places, however, unless very elaborate means are used to effect good air distribution, in which the air temperature will be too high for still-air cooling, and where movement will be essential to make conditions comfortable or even tolerable.

The next point is that formula (6)

$$H_1 = H_0 \left(\frac{1 + \sqrt{\frac{P_1}{P_0}}}{2} \right)$$

applies only to cooling in still air. In case a general formula might prove of interest to those who wish to calculate with some exactitude, from meteorological data (temperature, humidity and wind) the cooling powers at high altitude, I offer the following:—

$$\frac{H}{\theta} = \cdot135 + \cdot135\sqrt{\frac{P}{P_0}} + \cdot49\sqrt{V\frac{P}{P_0}}$$

At the altitude of the Rand this becomes

$$\frac{H}{\theta} = \cdot256 + \cdot41\sqrt{V} \qquad \text{(Compare 2.)}$$

I am afraid Mr. H. Pirow has misunderstood me somewhat and is under the impression that I advocate a CO_2 standard of 2 for underground. I think the less CO_2 the better. What I tried to show was that it was more important to obtain adequate cooling power, even by local stirring up, if necessary, than to obtain low percentages of CO_2 of the order required by the usual ventilation rules.

With regard to wet-bulb temperature, although this is of considerable importance, I do not consider a standard wet-bulb limit can be reasonably established. Except in still air, the wet-bulb temperature does not define the conditions of comfort, as the important factor of air movement is not included.

With regard to Mr. Woodburn's remarks on the anemometer and the inaccuracy of the kata as an anemometer in air currents which are eddying considerably, I wish to say that with one exception all the standard methods of measuring air velocity (for the purpose of computing the volume passing a certain section) fail in accuracy when the current is eddying badly or pulsating. I remember on one occasion a youth, who had been trained in the works of a large ventilating firm in London, when testing the output of a fan with a windmill anemometer, getting 100% more air at the discharge than at the intake, largely because while the intake was in regular stream lines, the discharge was pulsating, eddying, and irregularly distributed. The only accurate method I know of, which is independent of eddying, is that of supplying heat at a known rate to the air current. This can be accurately

effected electrically—the temperatures before and behind the position of heat supply are read and from quantity of heat supplied, the rise of temperature and the specific heat of air, the quantity of air passing is calculated. I am very sceptical of the accuracy of readings of air currents taken with the anemometer in underground drives and workings, where, as Mr. Woodburn says, the air is usually eddying considerably, or even back-washing in places.

I am indebted to Mr. C. J. Gray for his word of warning against action based on Kata readings alone. In my zeal to call attention to the importance of "cooling power" and "air movement" I may have given the impression that, in my opinion, nothing else mattered; and if that be so, I am glad Mr. Gray has presented me with the opportunity to correct it. I am with Mr. Gray entirely in his plea that the Kata should be used intelligently and with discrimination, and agree that air laden with fine dust should be treated as a poisonous gas—a slow poison, no doubt, but a sure one—to be removed or diluted by ventilation or other methods. It was impossible, in a 20 minutes' paper on the Kata, to cover these various aspects of mine ventilation, but in the paper by Dr. Orenstein and myself on "The Influence of Mine Atmospheric Conditions on Fatigue,"* in which there was more scope for dealing with mine ventilation, we distinctly say, in connection with the ventilation of raises, winzes and blind ends of drives, "that a continuous circulation of air in such places should be carried on during working hours, either by power or hand-driven fans, or by ejectors—whichever is the most economical—with the aid of canvas piping, drawing air from the drives where the general circulation is in action."

It may be that the use of the Kata and consequent efforts to get cooling power will induce a tendency towards less humidity, though I think the necessary cooling power can be obtained by other factors, such as lower temperature and movement. In any case, lower temperature will produce lower absolute moisture content and this, not relative humidity, determines the evaporation from the respiratory tract, which is most desirable to promote immunity from bacterial invasion. I am convinced that if the absolute humidity can be diminished without increasing the risk of dust it will be a considerable advantage.

In conclusion, I should like to specially thank Dr. Orenstein for help and advice in the preparation of the paper and for reading it for me at a time when I was not feeling fit enough to attend and read it myself. The mining industry have Dr. Orenstein to thank for introducing the Kata-thermometer to the Rand. With his usual readiness to appreciate a good thing when he sees it, when it was brought to his notice shortly after invention, he recognised the great value this instrument might be in mine ventilation; as soon as instruments could be obtained he commenced to make a "kata" survey of several of the mines, and has ever since been advocating its use on the mines. I trust that the good seed he has sown will bear abundant fruit and that before long the Kata-thermometer will be regarded as a necessary part of the testing equipment of every mine on the Rand.

* Journal of S.A. Institution of Engineers, March, 1921.

THE IDEAL MINING LAW.

By C. J. Gray.

(Printed in Journal, September, 1920.)

DISCUSSION.

Mr. W. A. Hirst (late Mining Commissioner, Barberton District): Mr. Gray's remark that "An ideal mining law is unobtainable" is very true, but the writer considers that the Transvaal law is satisfactory in many ways. There are, it is true, many unsatisfactory features, some of which will be referred to hereafter.

Title is good, and the registration in the Johannesburg and district offices can be relied upon. The information in the district offices is more up-to-date, because in the Johannesburg office only surveyed rights are registered, whereas in the district offices the compilation plans show all peggings which have not been surveyed in addition to those which have. Transfer of rights must be by deed and is easily effected at a moderate expense. In the Transvaal the districts are classed "A" and "B." "A" the Reef districts, and "B" the outside districts. In the former, rights to be transferred must be surveyed, but in the latter the Mining Commissioner may allow transfer on a sketch plan approved by him.

Mr. T. G. Trevor, in the April, 1920, number of the Society's *Journal*, deals at

length with the subject of obstacles to mining, and the writer heartily agrees with his views. To thoroughly appreciate the position to-day it may be stated that from a prospecting and mining point of view land is held as follows:—

(a) Private unproclaimed land.
(b) Private proclaimed land.
(c) Government proclaimed land.
(d) Government unproclaimed and deproclaimed land.

The "obstacle to mining" applies, principally, to (a) Private unproclaimed land. Here the Government, although satisfied from the reports of its officials that certain farms are mineralised, cannot touch them if the owner objects and proves that for three months in the year his farm has been used for agricultural or pastoral purposes—a very easy thing to do. To alter the position on the lines indicated by Mr. Trevor, a sweeping alteration of the law would be necessary, and this alteration is, in the writer's opinion, impossible to-day in view of the strength of the various political parties, because it must be borne in mind that the backveld farmer and the capitalist are equally affected. Until something of the sort is done the mineral resources of this Province will never be proved.

In the cases of (b), (c) and (d) the operations of the prospector are not hampered to any unreasonable degree. The land is already available for prospecting, and if it is not, the Mines Department will do all it can to make it so.

There is one point in connection with prospecting which the writer would like to lay some stress upon, and that is in connection with discovery rights. A discoverer gets every possible encouragement and assistance from the Mines Department, but he can get only one claim (every claim being 400 ft. by 150 ft.) for every sixty morgen of the area of the farm or lot (with a maximum of fifty in all). His award is notified in the *Gazette*, and the notice informs the public that no further prospecting is to take place on that farm or lot. Here is the "obstacle" which certainly ought not to exist. The writer has in mind two cases in his late district where the prospectors have been granted discovery rights, one for precious and the other for base metals. Their operations extended over a considerable distance outside the claims selected as the award and values were proved equally good all along, but, as the law says that no further prospecting is to take place, meaning, of course, that no further awards can be granted, that (possibly) valuable mineralised area is locked up unless the Government decides to proclaim, in which case the prospector who has done all the work and borne all the expense has to compete with the public for the ground he has proved.

The prospector, as the first step, obtains a prospecting permit (5s. per annum), which permits him to peg an area 2,000 ft. by 2,000 ft. (66⅔ claims). As he is not certain where he will make the discovery for which he will later on claim he obtains a number of other permits in borrowed names and pegs what he considers every likely spot. Once he has selected his ground the other permits are useless.

With regard to base metal discovery rights there is a curious anomaly which should be remedied. The intention of the law is to duplicate matters relating to base metals. One can peg 100 claims as against 50 gold, yet, when it comes to making a discovery award, the maximum is 50 as it is for gold. An oversight, of course.

Mr. Gray deals at some length with the holding of ground for speculative purposes. This is a very difficult point. Under the Transvaal law there are two methods of forcing or endeavouring to force a claimholder to work his ground (a) raising his licence money to 15s. per claim per mensem as against the 2s. 6d. he has been paying, and (b) giving him notice to work, and, on non-compliance, forfeiture follows.

Neither of these is satisfactory, because in

(*a*) He has no need to work if he pays the increased rate, and if the rate is once raised it cannot be reduced, even though the claim-owner subsequently begins to work; and as to

(*b*) Because it is too cumbersome. It would take, the writer estimates, anywhere from 8 to 12 months to reach the forfeiture stage.

Whether or not it is wise to forfeit for non-work is a very open question. As regards the Transvaal, the writer is not in favour of forfeiture for non-work, for many reasons which it is not within the scope of this paper to deal.

Under the heading, "Control of Mining," Mr. Gray touches on the subject of the pegging of base metal claims over what is considered gold reef. This is so, and unless the law is altered it cannot be prevented. The writer knows of cases where a claimholder has paid on his claims for years at

the gold rate of 2s. 6d. per mensem, has allowed the ground to lapse, taken his chance of re-pegging, has re-pegged as base metal and then paid his one penny per claim for 12 months and sixpence per claim afterwards.

The remedy is for the Government Mining Engineer to have the property thoroughly sampled, and, if satisfied, report that it is a gold proposition, not base metal. Thereupon the Department will call for licence money at gold rate. To the writer's knowledge this procedure has never been adopted, and, in his opinion, never will be. Claim-owners have told him that they would welcome such a report with glee, as it would be a Government guarantee as to the value of their property.

As regards the administration of the law I can truthfully say from my long experience that it is extremely satisfactory, and business is conducted as expeditiously as circumstances permit. Each district is to a very great extent de-centralised, and for all ordinary work the man on the spot can and does deal with it without delay.

There are many other features of the Transvaal Gold Law which it might be of interest to comment upon, but, as they refer mostly to details such as surface rights, stands, etc., they are scarcely relevant to this paper, but I may say that as far as outside districts are concerned the Mining Commissioner having a fairly free hand generally does his best to smooth the path of the prospector, and he usually succeeds.

This contribution is scarcely on the lines of what an ideal mining law should be; it rather takes the form of an uncomplimentary comment. Still, if the points raised were satisfactorily remedied they would go some way at all events towards the "Ideal."

CHEMICAL METHODS OF DE-AERATION OF WATER OF SOLUTIONS.

By H. A. White.

(*Printed in Journal, December, 1920.*)

DISCUSSION.

Mr. F. Wartenweiler: I think Mr. White's paper was a timely one, and, speaking from a metallurgist's point of view, we should all be only too happy if we were de-aerating all our solutions at present by either chemical or mechanical means. It may not be known generally that, concurrent with tests on chemical de-aeration the Chamber of Mines conducted a lengthy trial at the City Deep mine on mechanical de-aeration by vacuum, and, as a result of these trials, certain mines are being equipped with a view to adopting this method. It is perhaps unfortunate that de-aeration or de-oxidation by zinc which promises to be the most economical of the chemical methods is rendered impracticable by the fact that zinc precipitates the gold in the solution, and that when we eliminate the oxygen from the solution in our first compartment of a zinc box we also precipitate the gold. Although Mr. White's paper is comprehensive, I think there is further development along chemical de-aeration lines to be anticipated. I notice that there is a revival in the technical literature on chemical de-aeration of boiler feed water.

Mr. Thos. B. Stevens: In the *Journal* for December last an interesting paper by Mr. H. A. White was published on "Chemical Methods of De-aeration of Water and Solutions." As the subject of de-aeration is one which has been attracting a good deal of attention recently I should like to call the attention of members to the work which has been done in Western Australia in connection with the Coolgardie water scheme. The scheme now includes what I believe to be the largest de-aeration plant in the world.

The water is pumped from Mundaring to Kalgoorlie, a distance of 350 miles, through a 30-inch diameter steel pipe; in travelling this distance it is pumped eight times. Early in the life of the main there was a rapid increase in friction, and the inside of the pipe became heavily coated with rust nodules. A committee of experts who investigated the trouble advised that lime be added to the water, and also that it be de-aerated. The addition of lime alone was first tried and after using for some years was found to be inadequate. A de-aeration plant was then installed, and this has been so successful in stopping the corrosion, that the use of lime has now been discontinued. The de-aerator is of the mechanical type, the water being sprayed into a tower and subjected to vacuum, 90% of the dissolved oxygen is extracted, and the remaining 10% is found to be absorbed in the first 30 miles of pipe. The water as delivered to the mines at Kalgoorlie shows no oxygen by the alka-

line pyrogallate test. The amount of water delivered is 2,000,000 gallons.

Further information about this work can be obtained from a paper by O'Brien and Parr read before the Institution of Civil Engineers in 1917, and entitled, "The Coolgardie Water Suply, Western Australia."

The meeting then terminated.

Correspondence

A RICH NICKEL ORE.

To the Editor,

Journal of the Chemical, Metallurgical and Mining Society of S.A.

Dear Sir,

The remarks made by Mr. A. F. Crosse at the April meeting in reply to my discussion on the above subject appear to call for some reply.

In the original contribution, the nickel was stated as "oxide of nickel," and any chemist would naturally assume that NiO was the oxide meant. It now appears to be tri-nickelic oxide, Ni_3O_4, and Dana is given as the authority. I find that Dana (1901) gives a reference to this oxide, but the reference is dated 1878! None of the modern text books mentions it, so I take the liberty of disbelieving it.

I would suggest to Mr. Crosse that an estimation of the amount of chlorine evolved when the mineral is treated with hydrochloric acid would show him that Ni_3O_4 is absent from the mineral, and that therefore his published analysis adds up only to approximately 96%.

Mr. Crosse is a colleague; I would not therefore criticise his "technical and scientific opinions." I have intervened in this case only because his technical opinion appears to be unscientific.

Yours faithfully,

JAS. GRAY.

Johannesburg,
3rd June, 1921.

Notices and Abstracts of Articles and Papers.

METALLURGY

SPELTER MAKING IN SWANSEA.—Among the various metallurgical operations which have been carried on in South Wales for many years, the manufacture of zinc spelter holds an important place. The chief centre of the works producing this metal is in the neighbourhood of Swansea, where the following firms are established:—Vivian and Sons; Dillwyn & Co.; The English Crown Spelter Company; Williams, Foster & Co., and Pascoe, Grenfell & Sons; Swansea Vale Spelter Company, and Villiers Spelter Company. The older methods of manufacture have been discarded and the Belgian process is now used.

Spelter is extracted from various ores by a process of distillation. The only ores used in the Swansea district are calamine (a carbonate of zinc) and blende (a sulphide of zinc). In practice a mixture of both is used. Before the actual operation of distillation takes place, the ores have to be ground and screened to ensure that the material is in a state of fine powder. Further, it has to go through a process of roasting, or calcination, in order that the ore may be in the form of oxide of zinc. It is then ready for distillation.

In the case of calamine the ore is calcined near the mines, the only element to be displaced being the carbonic acid gas (CO_2)—a comparatively easy matter. In the case of blende the sulphur has to be expelled, and this process requires great care, as, for every particle—or atom—of sulphur which is left combined with the zinc in the ore after calcination, a corresponding amount of zinc is lost, owing to the fact that zinc sulphide does not yield its metallic content during distillation. Hence the roasting of the blende must be done as perfectly as possible.

The calciners used are generally hand worked. Mechanical furnaces have been tried, but have not so far found much favour.

One of the best hand-worked furnaces is known as the "Delplace" calciner. It consists of a series of shelves, built vertically one above the other, on which the ore is placed, and is heated in a portion of the furnace set apart for this purpose, in fire-places built below the bottom shelf of the roasting compartments. This portion which is fired is also supplied with an arrangement for admitting and heating air, which travels to the lower shelf of the calciner and thereby assists the oxidisation of the remaining portion of sulphur in the ore—which is being roasted—towards the end of the operation. When the blende has been thoroughly roasted it is raked out of the calciner and afterwards mixed with lime, salt and anthracite duff, and conveyed to the distillation furnaces. During the roasting process the sulphide of zinc in the blende has been transformed into oxide of zinc.

It should be pointed out that lime and salt are added to the ore merely as fluxing agents, the anthracite duff being the actual reducing agent employed to convert the oxide of zinc into metallic zinc or spelter.

The process of distillation is carried out in gas furnaces built with fire bricks. They have a regenerator system, similar to that employed in steel furnaces, for heating the air on its passage to the gas chamber where combustion with monoxide of carbon takes place. The monoxide of carbon is generated in gas producers, fed by a high volatile coal, which are in close proximity to the distillation furnaces. The portion of the distillation furnace where the gas is aglow contains the retorts or pots, which are charged with the prepared ore. These pots are connected with pipes on the outer part of the furnace, all crevices being clayed up during the process of distillation. When the ore in the retorts has been subjected to the heat of the gas

for some hours reduction takes place; the carbon of the anthracite duff unites with the oxygen of the ore, liberating zinc in the form of vapour. This vapour travels the path of least resistance outwards towards the pipes and condenses into liquid metal, which is drawn off during the tapping processes and run into moulds, where it solidifies as plates of spelter—the form in which this metal is usually sold. Distillation furnaces are charged once every day, and the yield varies with the size and number of retorts in the furnace; in some cases the production is about four tons of metal per 24 hours.

It is of interest to point out that the retorts, or pots, and pipes and other connections used in a distillation furnace are made in spelter works; hence a pottery is a part of every establishment, and great care has to be exercised in the mixing of the fire clays, etc., used in making these articles; in moulding and drying them—processes carried out in specially heated compartments—and in baking and annealing them, the final operations in making them ready for use.

The loss of metal content in the ore compared with other metallurgical operations is high—amounting to about 15%—but, of course, varies according to conditions. Some of the metal cannot be economically extracted; a portion is absorbed by the pots; and there are further losses, a portion being burnt at the outer part of the furnace through leakage. It is always the aim of the manufacturer to reduce these losses to a minimum.

A source of revenue to the spelter trade is the utilisation of the waste sulphur gases, generated during the process of roasting the blende, in the production of sulphuric acid. Some of the local firms actually produce this acid at their works, manufacturing some hundreds of tons per week as a by-product.

Spelter ores are widely distributed, but many of the older mines are entirely, or almost, worked out. Now the industry is mainly dependent on Australian concentrates for supplies of raw ore. Supplies have not been obtainable for many months owing to a strike at the mines. "Concentrates" are the zinc portion of the original ore separated from the other portion as far as possible by a special process, which is really tantamount to a concentration of the mined ore.

The uses of spelter are many. It is employed in the manufacture of galvanised sheets, zinc sheets, etc., which absorbs large quantities. At present, owing to high prices, the financial condition of many countries and other causes, the galvanised sheet trade is experiencing a slack period. Spelter is also an element in many alloys, such as brass, bronze, etc. It is also used in the manufacture of zinc oxide—a raw material of white paints and enamels—and Swansea can boast of two works making this speciality (John R. Down & Co., and British Zinc Products, Limited).

The outlook at present is not encouraging for the spelter trade, as the prices ruling for some time past are below the cost of production. The present rate of about £30 per ton scarcely covers the cost of raw ore calculated in terms of a ton of metal contents. South Wales is at a disadvantage as regards costs of production, partly on account of the necessity of importing the raw ore. When high wages, dear coal, and the increased cost of other materials are taken into account, it is not difficult to see that the cost of production is very high.

It is probable that large accumulations of stocks are responsible for the low prices prevailing. The works in the Swansea district have been closed down for some time, and until conditions are more favourable there seems little hope of restarting them. When prospects are brighter, if all concerned will heartily co-operate in the best interests of the trade, there is little doubt but that this South Wales industry will be able to regain its former prosperity.—*The Times Trade Supplement*, 18th December, 1920. (W. A. C.)

New Steel Deoxidising Alloys.—A co-operative investigation was started in America in June, 1918, to select, according to a systematic procedure, some new experimental deoxidising alloys for trial in steel manufacture. Seventy-three deoxidising alloys, all of possible value to steel makers, have been found to have melting points, when oxidised, somewhat below the melting point of pure iron—some of them considerably below. Of the new oxidisers the most fusible, and the melting point of their mixed oxides in deg. C., are as follows:—75% Mn, 24% Si, 1,228; 41% Mn, 59% Ti, 1,160; 49% Mn, 18% Ti, 33% Si, 1,130; 13% Al, 52% Mn, 35% Si, 1,121; 12% Al, 47% Mn, 41% Ti, 1,320° C.—J. R. Cain, *Iron and Coal Trades' Review*, Nov. 26, 1920, p. 724. (J. A. W.)

Anti-Corrosive Aluminium.—A method has been successfully tried for rendering aluminium and its alloys proof against rust. An electrolyte is made up of a sulphur compound of molybdenum and zinc employed as the anode, constituting a cell with the aluminium as cathode. By maintaining the cell at a temperature of from 60° to 65° the aluminium becomes covered with a dark brown coating which proves adhesive and rust-proof against the most stringent tests. The metal may be bent or rolled without cracking the coating, and has been immersed by way of test in a salt solution for two months without showing a trace of corrosion.—Anon., *Ind. Eng.*, Oct. 16, 1920, p. 215. (J. A. W.)

Changes of Address

Anderson, R. C., *l/o* Modderfontein "B" G.M. Co., Ltd.: Apex Reduction Works, P.O. Box 2, Benoni.

John, W. E., *l/o* Victoria Street, London: P.O. Box 583, Johannesburg.

Kenney, H. S., *l/o* Ottoshoop: P.O. Box 3541, Johannesburg.

Lindberg, A. W., *l/o* Ferreira Deep, Ltd.: Modderfontein "B" G.M. Co., Ltd., P.O. Modderbee.

Telford, Wm., *l/o* City and Suburban G.M. Co., Ltd.: Village Deep, Ltd., P.O. Box 1054, Johannesburg.

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NOTICE.

The next Ordinary General Meeting will be held in the Scientific and Technical Club, 100, Fox Street, Johannesburg (between Rissik and Loveday Streets), on **Saturday, 17th September, 1921, at 7-45 p m.**

THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA.

Vol. XXI. JUNE, 1921. No. 12.

Proceedings AT 25th Annual General Meeting, June 25, 1921,

The Twenty-fifth Annual General Meeting of the Society was held in the Assembly Hall, Scientific and Technical Club, 100, Fox Street, Johannesburg, on Saturday, 25th June, 1921, Mr. F. W. Watson (Vice-President) in the chair. There were also present:—

19 Members:—Prof. G. A. Watermeyer, Messrs. F. Wartenweiler, C. J. Gray, A. King, J. J. R. Smythe, John Watson, H. A. White, J. A. Woodburn (Members of Council), W. Beaver, Dr. W. A. Caldecott, R. A. Cooper, E. H. Johnson, C. A. Meiklejohn, S. Newton, T. K. Prentice, A. Thomas, J. Thorlund, W. E. Thorpe and J. T. Triggs.

3 Associates:—Messrs. G. J. V. Clarence, C. L. Dewar and O. A. Gerber.

2 Visitors and H. A. G. Jeffreys (Secretary).

The Chairman: Before opening the meeting, I wish to refer to the loss sustained by one of our Past Presidents, and most prominent members, Dr. J. Moir—I refer to the death of Dr. Moir's wife. I am sure it is the wish of everyone present that we should signify our sympathy with him. (All members present rose.)

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 21st May, 1921, as recorded in the May *Journal*, were confirmed.

ANNUAL REPORT OF COUNCIL.

The Secretary read the Annual Report as follows:—

The following is the Report submitted by your Council on the work of the Society during the past year:—

Accounts.—From the Statement of Revenue and Expenditure now before you, it will be seen that the result of the Society's operations for the year shows a nett loss of £101 7s. 11d., as compared with that of last year of £265 14s. 2d., or £115 14s. 2d., after allowing for the donation of £150 from the Society's funds to the Associated Scientific and Technical Societies of South Africa. Dealing with the expenditure side of the Account there is a slight increase in general charges chiefly due to increased postage rates. Printing and stationery are a trifle less than last year, though this account has had to bear the cost of printing a supply of the revised Constitution and Bye-Laws of the Society. The increase under Rent and Lighting is on account of the transfer of the Society's offices to the premises of the Scientific and Technical Club. The salaries account is considerably less than that of last year, while under the head of Transactions a profit is shown instead of a loss.

The loss incurred in the production of the Society's *Journal*, has, unfortunately, increased considerably, principally through the falling off in advertisements from the mining houses, though it must be pointed out that the figures include the cost of printing the Indexes for Volumes XVIII. and XIX., about £60, which sum should properly have been charged in the accounts of their respective years.

As regards revenue it will be observed that members' current subscriptions are practically the same, though there has been a falling off in those of Associates as compared with last year. As was to have been expected, the amount recovered on account of members' and associates' subscriptions in arrear is considerably less than last year, when those items included amounts collected in respect of the whole of the war period.

Entrance fees show an increase of £13 13s. Other items include a profit of £52

11s. on the sale of transactions of the Society, £38 7s. 9d. surplus on the Exhibition account, and £9 16s. 6d. in connection with the removal to new offices.

Turning to the balance-sheet, although the year's working shows a loss of £104 17s 11d., the Revenue and Expenditure Account is only reduced by £64 8s. 11d. This has been caused by the transfer of £39 19s. balance of the Exhibition Fund, a balance which has remained untouched in the books for seven years, and your Council considered that the time had arrived when it might justly be added to capital

Membership.—Forty-two new members have been elected during the twelve months under review, and the Council has admitted six Associates. Sixteen Members and twelve Associates have resigned, and your Council records with deep regret the deaths of the following members:—J. H. Houghton, J. V. Kelly and L. N. Wilson.

It will be remembered that in the report presented at the last Annual Meeting it was mentioned that it had been found necessary to strike off the roll a number of Members and Associates with whom the Society had lost touch, on account of the war, while others were classed as doubtful. This year your Council has deemed it desirable to write off further names with the object of showing as nearly as possible the true number of active members of the Society.

Papers and Journals.—The high standard of original papers and contributions with the resultant discussions, has been well maintained, while your Council has endeavoured to broaden the scope of the Society by introducing greater variety in the choice of subjects.

The following original papers have been published during the year:—

July, 1920.—"Investigations made with the Konimeter to Ascertain the Amount of Dust Produced in Drilling Holes by means of Dry Jack Hammer Machines," by H. E. Barrett.

August, 1920.—"A Resumé of Literature on the Theory of Flotation with Critical Notes." by H. R. Adam.

September, 1920.—The President's Address, "Welfare Work on the Witwatersrand," by James Chilton.

"The Ideal Mining Law," by C. J. Gray.

October, 1920.—"Notes on the Influence of Soluble Silica and Calcium Salts on Precipitation," by J. Hayward Johnson.

November, 1920.—"Notes on Experiments on Ventilation Problems in Development Work on Mines," by E. J. Laschinger.

"The Kata Thermometer and its Practical Uses in Mining," by H. J. Ireland

	June, 1899	June, 1900	June, 1902	June, 1903	June, 1904	June, 1905	June, 1906	June, 1907	June, 1908	June, 1909	June, 1910
Hon. Members	8	14	9	13	18	18	16	17	18	21	22
Life Members	1	1	1	1	2	3	4	7	7	8	9
Members	197	281	291	441	639	680	680	683	618	630	731
Associates	180	238	213	281	338	321	314	342	357	342	402
Students	—	—	—	—	4	8	1	7	18	20	60
	386	534	514	736	1,001	1,030	1,018	1,056	1,018	1,021	1,224

	June, 1911	June, 1912	June, 1913	June, 1914	June, 1915	June, 1916	June, 1917	June, 1918	June, 1919	June, 1920	June, 1921
Hon. Members	20	23	25	25	26	26	25	23	22	21	24
Life Members	9	9	10	10	10	9	9	9	9	10	10
Members	711	733	618	550	481	463	454	469	463	340	363
Associates	380	442	396	351	287	272	263	270	270	178	166
Students	57	22	21	15	2	3	5	2	2	6	—
	1,177	1,229	1,070	951	806	773	756	773	766	555	563

"Cementation of the Substrata of the Mazoe Dam Retaining Wall," by G. A. Voskule.

December, 1920.—"Chemical Methods of De-aeration of Water of Solutions," by H. A. White.

January, 1921.—"Treatment of Antimonial Gold Ore at the Globe and Phœnix Mine, Southern Rhodesia," by V. E. Robinson.

February, 1921.—"Fire-Damp in the Gold Mines of the Far East Rand," by T. N. Dewar.

March, 1921.—"Symposium: Miners' Phthisis," contributions by Dr. A. J. Orenstein, Dr. A. Mavrogordato, C. J. Gray, L. Harris and H. A. White.

April, 1921.—"Methods Used in the Detection and Investigation of Vitamines," by Dr. E. M. Delf.

"Symposium: Miners' Phthisis," contributions by E. S. Hendrikz, E. M. Weston, W. Allen and H. C. F. Bell.

May, 1921.—"Notes on Some Technical Methods of Analysis," by A. Whitby and J. P. Beardwood.

"Notes on Some Reactions of the Xanthates," by A. Whitby and J. P. Beardwood.

"Symposium: Miners' Phthisis," contributions by H. J. Ireland and H. C. F. Bell.

Associated Scientific and Technical Societies of South Africa.—During the year very great strides have been made towards the realisation of the scheme for a joint home of the Scientific and Technical Societies. The premises which had recently been acquired at the date of the last Annual Meeting are now known as the Scientific and Technical Club. They have been put into thorough repair and well fitted and furnished throughout, while a restaurant and tea room have been opened for the convenience of Members, and it is expected that the Club Bar will be opened in the beginning of next month. Generous donations to the funds of the Associated Societies have been received from Members of this Society and their friends, but there are still some who have not yet come forward, and it is hoped that those will lose no time in affording tangible support to this institution, and will also patronise the Club on every possible occasion. Now that the ideal of "Closer Working and Joint Housing" has so nearly approached achievement it is incumbent upon every Member of each Society concerned to do his utmost to make certain of the ultimate success of the scheme. In February last this Society transferred its offices from the University College Buildings to the Club premises.

Research Endowment Fund.—This fund which appeared as £156 15s. 11d. in the last balance-sheet, now amounts to £395 0s. 10d., and out of the revenue accrued therefrom your Council intends to award Gold Medals for the best papers read before the Society. These awards will be declared shortly.

The Exhibition.—The title of the Fifth Chemical, Metallurgical and Mining Exhibition was adopted this year as better representing the scope of the undertaking. The Exhibition was held in the Scientific and Technical Club from the 9th to the 19th of March last, and was opened by Sir Lionel Phillips, Bart., Honorary Vice-President. Mr. James Chilton, in welcoming Sir Lionel, paid tribute to the interest which he had manifested in the work of the Chemical, Metallurgical and Mining Society. For many years, Sir Lionel had been connected with the Society, and, in 1894, when it was formed, he was one of their strongest supporters, and in the long years which had passed since then they had always had his assistance. A short time ago they had proof of his regard for and interest in the Scientific and Technical Societies by the very material support which he had influenced on their behalf, of which the building in which they then met was a tangible result. In a thousand ways Sir Lionel had helped them; for many years his connection with the Society had been very close, and at present he was an honorary Member, and one of their most valued adherents. Sir Lionel was not only sympathetic to their Society, but to every institution which had the good of the community at heart.

Sir Lionel Phillips having acknowledged the compliment paid him by the Chairman in respect of the little service he had gladly rendered the Society, proceeded to say that if there was one thing they in Johannesburg could feel proud of, it was their scientific Societies. The activities of the Society were not confined to the main industry of the country, but all came within their purview, and therefore it was but right that people should do all in their power to advance the interests of an institution of that character. The Society, he believed, was the oldest in Johannesburg—it was formed in 1894 or 1895, as the Chairman had informed him—and during its lifetime splendid work had been accomplished in the matter of solving chemical, metallurgical and mining problems, which had been studied and discussed in a manner which proved of immense benefit.

Intimating that he had been invited to preside on Friday evening at Dr. Orenstein's lecture on "Miners' Phthisis" Sir Lionel went on to say that that was a subject which he had studied very carefully. This disease was a terrible scourge, and one which was of immense disadvantage in the gold mining industry; he was pleased to say,

however, there were signs of its gradual disappearance. Remedies were being applied to-day, and other preventive steps were being taken with the view to combating the disease, which, he hoped, would soon be blotted out entirely. People were somewhat chary in letting their sons come out to a place in which this fell disease prevailed, but he hoped that within the near future the cause of this would be completely removed. During and since the war it had been necessary to take a number of men into the mining industry whose qualifications were not the best, but he trusted that in course of time they would feel proud of the mining men, upon whom depended the success of the industry as well as the example which was set the native population. The exhibition was a tribute to the skill and thought given by scientific men on the Rand to the development of new appliances and improvements, which, not only in Johannesburg but throughout the world, would revolutionise things in many directions.

They should feel very proud of their scientific societies, and he hoped they would continue to meet with the success they deserved.

Referring to the question of pneumonia among natives, Sir Lionel said the strides which had been made in the matter of prevention of this complaint were astounding when compared with the evil effects which it had had in the early days. He hoped that the interest in the Exhibition, which had been more or less affected by the intervention of the war, would be accentuated in future, and that it would add to the usefulness and prestige of their scientific societies. He had great pleasure in declaring the exhibition opened.

Mr. Jas. Gray, in proposing a vote of thanks to Sir Lionel, said the Society was under many obligations to him, and to-day he had placed them under a still further obligation by opening the Exhibition. Sir Lionel was no longer permanently with them, but the glamour of South Africa still called him at intervals, and it was their good fortune that one of those intervals had coincided with the Exhibition.

The opening was exceedingly well attended by a large number of Members of the Society and others connected with the industries. The Exhibition was of a highly successful character, and was visited, it is estimated, by some 8,000 people. The exhibits were all interesting, and many of a high educational value. It is to be regretted that the individual exhibits of original inventions and labour-saving devices were fewer than in previous years, but it is hoped that next year it will be possible to secure a larger building, as well as open-air space, and present an Exhibition on a greater scale than has yet been attempted.

While the Exhibition was open the following evening lectures were given:—

"Miners' Phthisis," by Dr. A. J. Orenstein, C.M.G., illustrated by a film specially prepared by the African Films Trust, Ltd., for the Transvaal Chamber of Mines.

"Efficiency in Mining," by Mr. R. H. Wonnacott, Superintendent Government Miners' Training Schools on the Witwatersrand

"Mine Accidents," by Mr. L. G. Ray, A.R.S.M., Assistant Inspector of Mines, Johannesburg District.

The usual *Safety First Competition* was held for the medals presented by the Rand Mutual Assurance Co., Ltd., and twelve entries were received. Reference to the awards appeared in the April number of the *Journal*.

Annual Dinner.—In view of the financial loss incurred on account of the last Annual Dinner, your Council reluctantly decided to abandon the function for this year, but it is hoped that, with the more favourable facilities which will be afforded by the Scientific and Technical Club, it will be revived at an early date.

Council.—Nine meetings of the Council have been held during the year, as well as several Committee meetings. The attendances at the Council meetings averaged 12·2, and were as follows:—

J. Chilton[1] ...	... 6	E. Pam[4] ...	... 2
F. Wartenweiler[1]	... 6	J. J. R. Smythe	... 8
G. A. Watermeyer[2]	... 6	J. Watson ...	... 8
F. W. Watson	... 8	E. M. Weston[2]	... 1
J. R. Thurlow[3]	... 4	A. Whitby ...	... 3
H. R. Adam[1]	... 5	H. A. White[2]	... 6
C. J. Gray ...	... 9	J. A. Woodburn	... 9
C. H. Greathead[1]	... 3	J. Gray[6] ...	... 7
J. H. Johnson	... 7	G. H. Stanley[6]	... 1
A. King[5] ...	... 3	J. A. Wilkinson[6]	... 4
A. J. Orenstein[2]	... 5		

Leave of absence granted for (1) three meetings; (2) one meeting; (3) four meetings; (4) resigned, Feb., 1921; (5) elected, Feb., 1921; (6) Past-Presidents.

The Council desires to place on record its appreciation of the services rendered by the Honorary Auditor and the Honorary Legal Advisers, and also by the following Committees:—Finance: Messrs. J. R. Thurlow, F. Wartenweiler, J. Chilton, J. J. R. Smythe and J. Watson. Editorial: The President, Messrs. H. R. Adam, C. J. Gray, Dr. J. Moir, Prof. G. A. Watermeyer, F. W.

Watson, H. A. White and Prof. J. A. Wilkinson. Mining Exhibition: The President, Messrs. J. H. Johnson, H. S. Meyer, F. Wartenweiler, John Watson and J. A. Woodburn. Delegates to the Controlling Executive of the Associated Scientific and Technical Societies of South Africa: Messrs. J. Chilton and J. R. Thurlow, and their deputies while on leave of absence, F. Wartenweiler and F. W. Watson.

The Chairman: In moving the adoption of the Annual Report and Financial Statement, I should like to draw attention to a few points of interest.

Dealing with the financial side, the loss of over £100 given in the report requires some explanation. Exceptional expenditure has been undertaken during the year under review. This is due to printing three sets of indexes instead of one, and printing the amended Constitution and Bye-Laws. If these exceptional items were eliminated the loss shown would be decreased by £88. It must, however, be remembered that the expenditure in the following year will be increased on account of the Society having to pay a bigger rental for the new offices in this building.

On the revenue side the two main sources are subscriptions and advertisements.

With regard to the former, we must all do our best to enrol new active members. The revenue from advertisements has fallen off as the mining houses cannot be so liberal in their advertisements owing to the state of the industry. On the whole, considering the difficult times through which we are passing, I think we may congratulate ourselves on coming out with such a small loss, and hope that our affairs will improve, but this will require steady and sustained effort.

The increase in membership during the past year is gratifying; we regret resignations, but the Council, as before, is ready to consider sympathetically applications for reinstatement. The losses by death, it is pleasing to note, have been few.

The papers read before the Society during the year have been of a high standard, but more are required. The Council is anxious to widen the scope of the papers, and, in view of probable industrial expansion, it is hoped that this wish will be gratified.

The most noteworthy feature of the Society's activities during the year is the removal of our offices to the new Club buildings, and the alteration of the venue of our meetings from the University College to this hall.

The Scientific and Technical Club is now well established, a restaurant is at present being conducted under most capable management, and a licence has been granted. It is hoped that members will support these new institutions.

Another feature in the year's working is the change in the Constitution and Bye-Laws, whereby the Past Presidents are eligible for re-election to the Council. It is hoped that this will stimulate the interest of these gentlemen who have passed the chair. Unfortunately, this year only four accepted nomination.

The Exhibition has been dealt with at length in the Report, and it is to be hoped that there will be more space for the exhibits in the future; the financial result was gratifying, a profit of over £38 having been made.

The Annual Dinner was allowed to lapse this year as this social event has not received the support from members that was expected, and in consequence it was a failure, financially, last year. The Council felt that the Society was not in a position to face a further possible loss, and that the only course open was to abandon the dinner.

The sum invested in the Research Endowment Fund is very satisfactory, but we hope that this will be increased so that the Society can carry out fully the objects set forth in the *Journal* of June, 1920.

The attendance at Council meetings has been good, and an improvement on last year, when the average was between 10 and 11.

I have much pleasure in moving the adoption of the Report and Statement of Accounts.

Mr. F. Wartenweiler: I have much pleasure in seconding the adoption of the Annual Report. I think the Report deals rather fully with the financial side, and our Chairman has prefaced it still more.

As I have acted for the last four months as Treasurer, I have naturally taken a great deal of interest in the finances, and I have discovered that it is a very difficult matter to forecast the future, or forecast the coming year, with any accuracy, or to bring out any budget. Undoubtedly it would be of service, financially speaking, to have a budget in order that we might arrange our expenditure accordingly. However, I have felt all along that, although our resources in cash may be rather low and may

THE CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA.

(INCORPORATED MAY, 1907.)

REVENUE ACCOUNT for the year ended 31st May, 1921.

Dr.

1919-20 £ s. d.	EXPENDITURE.	1920-21. £ s. d.	£ s. d.
	To CHARGES (including Postages, Bank		
(88 8 3	Charges, Insurance, etc.) ...	100 2 11	
167 1 9	,, PRINTING AND STATIONERY ...	159 17 8	
26 14 7	,, RENT, LIGHTING AND TELEPHONE...	60 4 3	
778 10 9)	,, SALARIES	662 7 1	
1060 15 4			982 11 11
	,, SOCIETY'S JOURNAL—		
(828 15 4	Cost of Reporting, Printing, etc.	713 2 0	
	less Received for Subs. and Advts.		
758 11 6)	after deducting commissions on		
	Advts. and Collections ..	528 10 3	
70 3 10			184 11 9
	,, GRANTS AND PRIZES—		
5 5 0	*Prizes for Papers submitted.*		
(25 0 0	Grant to Seymour Mem. Library	25 0 0	
8 8 0)	Prizes University College, Jo'burg	6 6 0	
38 13 0			31 6 0
(36 13 9	,, *Transactions: Cost of binding, etc.*		
6 13 9)	*Less Sales*		
29 10 0			
	,, *Donation to Associated Scientific and*		
150 0 0	*Technical Societies of S. Africa*		
20 4 6	,, *Loss on Annual Dinner*		
£1369 6 8			£1198 9 8

Cr.

1919-20 £ s. d.	REVENUE.	1920-21. £ s. d.	£ s. d.
	By SUBSCRIPTIONS—		
622 18 3	Members, current year ...	627 5 6	
124 19 0	do. arrears collected ...	64 6 3	
224 4 0	Associates, current year ...	187 19 0	
76 2 6	do. arrears collected ...	46 3 6	
3 3 0	Students		
1051 6 9			925 14 3
29 8 0	,, ENTRANCE FEES		43 1 0
	,, INTEREST ON FIXED DEPOSITS AND		
22 17 9	SAVINGS BANK ACCOUNT ...		23 6 3
	,, TRANSACTIONS—		
	Sales	84 2 0	
	Less Cost of Binding, etc. ...	31 11 0	
			52 11 0
	,, Receipts *re* Fifth Chemical, Metallurgical and Mining Exhibition ...	315 5 0	
	Less Expenditure	276 17 3	
			38 7 9
	,, Sundry Receipts *re* sale of paper shelving on removal	26 10 0	
	Less Removal Expenses ...	16 13 6	
			9 16 6
	,, Receipts *re* Annual Dinner, 1920 ..		1 5 0
			1094 1 9
	,, BALANCE, being excess of Expenditure over Revenue for year ...		
265 14 2			104 7 11
£1369 6 8			£1198 9 8

BALANCE SHEET, as at 31st May, 1921.

Dr.

1919-20 £ s. d.	LIABILITIES.	1920-21. £ s. d.	£ s. d.
(363 9 2	To SUNDRY CREDITORS		334 14 1
26 5 0	,, SUBSCRIPTIONS paid in advance ...		30 9 0
	,, ASSOCIATED SCIENTIFIC AND TECHNICAL SOCIETIES OF S. AFRICA ...		
10 14 0			3 4 0
	,, RESEARCH ENDOWMENT FUND AS		
506 15 11)	PER CONTRA		395 0 10
647 4 1			
	,, REVENUE AND EXPENDITURE ACCOUNT—		
(680 16 2			
265 14 2)	Balance at 31st May, 1920 ...	415 2 0	
415 2 0			
	,, *Add* Balance of old Mining Exhibition Fund transferred		
39 19 0		39 19 0	
		455 1 0	
	Deduct Excess of Expenditure over Revenue for year ending May 31st, 1921	104 7 11	
			350 13 1
£1102 5 1			£1114 1 0

Cr.

1919-20 £ s. d.	ASSETS.	1920-21. £ s. d.	£ s. d.
	By CASH—		
119 7 3	Standard Bank of South Africa, Ltd., Johannesburg	33 1 0	
130 15 3	Standard Bank of South Africa, Ltd., London	56 18 10	
17 14 7	On Hand	3 18 10	
181 0 5	Standard Bank of South Africa, Ltd., Savings Bank Account with Interest accrued	6 2 6	
511 1 7	On Fixed Deposit with Interest accrued	512 18 0	
			612 19 2
	,, TRUSTEES "RESEARCH ENDOWMENT FUND"...		395 0 10
62 6 0	,, SUNDRY DEBTORS		61 1 0
45 0 0	,, OFFICE FURNITURE ...		45 0 0
35 0 0	,, *Stationery on Hand*		
£1102 5 1			£1114 1 0

We have examined the above Balance Sheet and accompanying Revenue and Expenditure [illegible] explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the affairs of the Society, according to the best of our information and the explanations given to us and as shown by the Books of the Society.

Acting Hon. Treasurer.

(Signed) H. A. G. JEFFREYS.

THE CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA RESEARCH ENDOWMENT FUND.

REVENUE AND EXPENDITURE ACCOUNT FROM INCEPTION OF FUND to 31st MAY, 1921.

Dr.			Cr.	
To Expenses—			By Donations Received ...	£386 5 0
Cheque Book and Deposit Book	£0 5 0		,, Interest received ...	9 13 4
Cash Book and Rubber Stamp	0 12 6			
		£0 17 6		
,, Balance		395 0 10		
		£395 18 4		£395 18 4

BALANCE SHEET, 31st MAY, 1921.

To Accumulated Funds—		By Investments—	
Balance of Revenue and Expenditure Account	£395 0 10	£400 Union of South Africa 5% Stock at Cost	£375 0 6
		,, Cash on Hand	20 0 4
	£395 0 10		£395 0 10

seem to be on the decrease, we have latent resources in our membership, and that with the devotion and loyalty which we can expect from the members of the Society, we shall retain our financial feet.

I would just like to say a few words in appreciation of the services of our Secretary, so, with your permission, I put on record our appreciation of his services for the past year. I think all of us who have worked with him have found him most capable, and we can consider ourselves very fortunate in having Mr. Jeffreys in the present position. Mr. Jeffreys has been zealous in our interests and whole-hearted. Gentlemen, I wish to second the adoption of the Annual Report.

The adoption of the Annual Report and Statement of Accounts was passed unanimously.

The Chairman: The next business is the declaration of the result of the ballot for officers and Council for the ensuing year.

Johannesburg,
25th June, 1921

The Chairman,
Annual General Meeting,
Chemical, Metallurgical and Mining Society of S.A., Johannesburg.

Dear Sir,

Election of Officers and Council for the year ending June, 1922.

We have to report that we have inspected the Nomination Papers, and received seventy-two closed envelopes containing Ballot Papers, and as a result of our scrutiny we find that the following gentlemen have been elected:—

President: Mr. F. Wartenweiler (unopposed).

Vice-Presidents: Prof. G. A. Watermeyer, Messrs. F. W. Watson and C. J. Gray.

Hon. Treasurer: Mr. J. R. Thurlow (unopposed).

Members of Council:

Dr. A. J. Orenstein.	Mr. E. H. Johnson.
Mr. H. A. White.	Mr. A. Whitby.
Prof. J. A. Wilkinson.	Mr. J. A. Woodburn.
Mr. H. R. Adam.	Mr. J. H. Johnson.
Mr. J. Watson.	Mr. J. E. Thomas.
Mr. H. S. Meyer.	Mr. A. King.

Yours faithfully,

Scrutineers. S. Newton. Percy T. Morrisby. A. Thomas.

The Chairman: I am sure the Society is very fortunate in having Mr. Wartenweiler as its President for the ensuing year. He has started his year well by giving us a paper on the night of his election.

Mr. W. Wartenweiler: I should like to express my sincere appreciation to you for the honour you have conferred upon me in electing me your President. It shall be my utmost endeavour, with the assistance of the able members whom you have elected to the Council, with their co-operation and with the co-operation of the members of the

Society, to maintain the traditions of the Society and to carry on the useful services for which it has been noted for the past 27 years. Gentlemen, I thank you.

Prof. G. A. Watermeyer: On behalf of the Vice-Presidents, I beg to tender you our thanks for our election. You have done two of us a great honour in re-electing us to this position, and, on behalf of the new member, I beg to tender you his thanks as well. Of course, in the daily round of our lives we are not able to give all the time we wish to the duties which devolve upon us, but we shall do our best, and I hope that with a little consideration on your part, you will find we are not wanting.

It is also my pleasant duty to propose a vote of thanks to the scrutineers in the conduct of their arduous duties.

Mr. E. H. Johnson: Mr. President and gentlemen, I should like to associate myself with Mr. Watermeyer in thanking the scrutineers for their efforts. One or two of them have had quite a lot of practice in past years. (Hear, hear.) I should also like to thank you on behalf of the new members of Council for having brought us to this honourable position. Some of us are perhaps a little stale and out of practice; but I can promise you we shall do our level best to maintain the high status of the Society.

Mr. S. Newton: Mr. Chairman and gentlemen, I wish to thank you for the very kind remarks you have made about the scrutineers. Some of us go a long way back. I recollect the first meeting, although I was not a member, in 1894. It is a pleasant duty to come in this time because we have had our introduction to the new Club, and it is certainly something, to my idea, that we should advertise; it is something like a home. Although I am at the other end of the Reef now, I shall make it my duty to advertise it as much as possible. I think my friend, Mr. Thomas, here, the other scrutineer, and I, have spent most of the afternoon in the Club easies, and partaken of all the good things you can get here, and I hope to be able to turn up again in twelve months' time to do the same. I thank you.

The Chairman: I should like to move a hearty vote of thanks to the Honorary Auditors, Messrs. Alex. Aiken and Carter, and to the Honorary Legal Advisers, Messrs. Van Hulsteyn, Feltham and Ford, for their services during the past year, and to move that they be re-elected.

The votes of thanks and re-election were agreed to unanimously.

NEW MEMBERS.

The ballot was taken for the election of new members, and the following were declared unanimously elected:—

Bilbrough, James Francis, P.O. Box 413, Johannesburg. Managing Secretary, Rand Mutual Assurance Co., Ltd.

Innes, John, P.O. Box 1021, Johannesburg. Mining Engineer. (Transfer from Associate Roll.)

GENERAL BUSINESS.

The Chairman: There is a letter here from one of our Past Presidents, Mr. Cullen. He writes:—

16th May, 1921.

I wonder if you can supply me with the following missing numbers of the *Journal*, viz.:—

1915, Vol. XV., Index.
1916, Vol. XVI., No. 10.
1919, Vol. XIX., Index.
1920, Vol. XX., No. 11.

If I can procure these my set will be complete, and if they are of any use I propose to present them, through you, to the Scientific and Technical Club if it proposes to form a library. I would deliver them f.o.b. here, and the only charges the Club would have to meet would be freight to Durban and railage up. Both these would be small, and there would be no duty.

(Signed) WM. CULLEN.

I think it is exceedingly kind of Mr. Cullen to offer this gift to the Society. He is one of our Past Presidents, and at one time was a very prominent member. He has also been a Corresponding Member of Council for many years; I hope his good example will be followed by others, and that the Scientific and Technical Club will receive more gifts. The Council has sent him a letter thanking him for his offer, and we hope that the numbers of the *Journal* he asks for will be easily got together.

DISTRIBUTION OF GOLD IN BANKET ORE CLASSIFIED PRODUCTS WITH REFERENCE TO MILLING AND CYANIDING OPERATIONS.

By F. Wartenweiler.

The constituents of the banket and of the associated quartzite, shale and dyke rocks, which constitute the ore treated have been described by a number of investigators: the most familiar description is perhaps that by R. Young, in the book entitled "The Banket." Both A. F. Crosse and Dr. W. A. Caldecott dealt with the constituents of the milled ore many years ago.* Lack of detailed information and the necessity of knowledge on the subject being brought abreast of current practice led to an investigation, the main features of which I shall endeavour to put before you. It was begun several years ago at the Rand Mines Laboratory, with the primary object of ascertaining the gold distribution in the ore constituents of the products into which the comminuted ore is classified after amalgamation. Since then the information gained by the method, when applied on samples from different mines, has been found to be of considerable use in controlling reduction works operations.

For the purpose in view it was thought that if a clean separation were made between the pyritic and the gangue portions and their relative gold value determined, the information sought would be acquired. After preliminaries with Sonstatt solution and with flotation, the latter method was decided on as preferable. Tests were begun, using a motor-operated laboratory, flotation machine, supplemented by panning of the tailing to separate any coarse pyrite and gold which had not been lifted with the froth. All samples for flotation were ground to pass a 150 mesh linear screen.

Various flotation oils were given a trial, the combination finally adopted as the most effective being wood tar oil and turpentine —in a circuit acidified with sulphuric acid.

It was found necessary to vary the amount of acid with the class of product treated. A final washing effect in respect to pyrite, was secured by the addition of a fractional quantity of wood tar oil toward the end of the flotation agitation. The separation of the pyritic portion was, by observation, clean, this being confirmed by sulphur determination in the tailing, which gave such low sulphur content in terms of pyrite as 0·16% FeS_2 and 0·08% FeS_2.

Perhaps it should be stated before proceeding that this paper is not intended as, nor does it claim to be descriptive of flotation tests on banket ore, although considerable data in this respect are shown. Flotation only served as a means in obtaining the information sought.

As free gold, not encased, will float in the frothing process, the pyrite, unless otherwise noted, also includes this floated gold. Its incidence was ascertained in several tests. No distinction was made between the argillaceous and the siliceous portion of the gangue. It is known that the truly argillaceous portion is small at the mines of the central district, but is increased at the extreme Eastern mines by the inclusion of much shale.

Series A. and B.—The first data were derived from tests on samples from the Ferreira Deep Reduction Plant. These tests were carried out in two series, one in which the agitation and frothing was continued to an extreme extent with the object of insuring a clean, pyrite free, tailing, and the other in which flotation was carried on only to the limit of the clean mineral froth stage, the object being to obtain a clean gangue free pyrite. The results are shown in tabular form (References 1 and 2).

From these it will be noted that the argillaceous and siliceous portion of the slime residue contains the greater part of the gold (60·1%), while the gold in the cyanide pulp is found to the extent of 87·5% in the pyrite portion. In Series B. the percentage of pyrite by weight, separated by the flotation method, plus panning, corresponds closely with the FeS_2 calculated from sulphur determinations. From a study of this record it is evident that the gold in the pyrite portion of the slime charge dissolves readily in cyanide solution.

Series C.—Further tests were conducted on a sample of cyanide pulp, and on a sample of sand charge, and the corresponding residue from the Village Deep Plant. It will be seen in referring to the charts (Ref. 3) that the gold in the cyanide pulp is distributed 37·5%, 51·4% and 11·1% respectively as free gold, in pyrite and in gangue. When investigating the sand charge

* *Journal of Ch. Met. and Min. Soc. of S.A.*, Vol. IV., 1903-04, pages 104 and 110.

Transactions of Inst. of Mining and Metallurgy, Vol. XIV. 1904-05. The Finer Crushing of Banket Ore, by W. A. Caldecott.

and residue, gold encased in the siliceous matrix was determined by the aqua regia method (Ref. 4). It does not appear to play much of a part in the residue. If the seal of accuracy be attached to this method of determination, one would accept as established that the cyanide solution penetrates the ore particles and dissolves encased gold. The amount of gold amalgamable in cyanide pulp and in the sand charge (Ref. 3 and 5), 37·5 and 19·4 respectively, varies with the grinding. It is a revelation, and confirms the general tendency in practice to throw more responsibility for gold recovery on the cyanide section of the plant and less on amalgamation. In considering the distribution of free gold, pyrite and gangue (Ref. 6) it will be observed that the first two comprise 90·3% of all the gold in the charge.

Series D.—A comprehensive series of tests were carried out on a City Deep sand charge and the corresponding residue. Free gold was not determined in this series, and is, therefore, included in the pyrite value. Under pyrite content (Ref. 7 and 10) it will be noted that the per cent. of gold content increases considerably in the gangue portion of the residue, evidently due to encased gold (Ref. 8). Grading analysis (Ref. 9) discloses the increase in gold percentage content in the coarser gradings, comparing the charge with the residue. The large amount of pyrite by weight and the importance of gold content in the minus 200 mesh grading of the charge (Ref. 10) is significant, especially when viewed in the light of improvement to extraction on this fine pyrite (Ref. 12). All the information under "distribution of gold extraction," and "extraction on pyritic portion" (Ref. 11 and 12) points to the great importance of grinding the maximum amount of pyrite and gold as fine as possible to pass the 200 mesh at least, in order to obtain the highest extraction.

Although this has been accepted as an axiom by many workers in this field, it is the aim of this paper to so illustrate and visualise it that it will become forcible to all those interested. From a practical metallurgical standpoint this investigation points to this one significant fact of the need for comminution of the pyrite.

The importance of careful classification and tube milling follows. If the classifiers do not return the + 200 mesh pyrite and free gold to the tube mills for further grinding then the plant is indeed handicapped. On the ores of the extreme Eastern district the application of this maxim is of the greatest importance.

The Chairman: I have much pleasure in proposing a very hearty vote of thanks to Mr. Wartenweiler, our new President, for his very interesting and able paper. I think we all knew that a great proportion of the gold is associated with the pyrite, but it is rather wonderful to see that so much is contained in this small proportion of between two and three per cent. of the total. This paper must have entailed a great deal of work, and is novel in that flotation has been carried out on the banket for separation. The accumulation of data, the putting the facts together, and getting all these diagrams drawn out is no small task, and I think we owe a debt of gratitude to the author for bringing this subject forward. It ought to lead to some valuable discussion.

Mr. H. A. White: I have very much pleasure in seconding this vote of thanks, and I congratulate the Society on receiving from the corporation which Mr. Wartenweiler represents, some of the details of the work of which no doubt so much has been carried out in the past. This is a sample of it; the sample is good; we should like some more of the bulk.

There is one thing one would like to remark on in connection with experiments of this kind—that is, that on the whole of the Reef we are really conducting large scale experiments every day; but when we get the results and turn them into the form of statistics, we find the usual destination of these statistics is burial in the Head Office; they are not collated and presented in such a form that profitable deductions can be made. For instance, on the East Rand, as Mr. Wartenweiler points out, this attention to finer grinding will possibly turn out to be of greater importance than even on the Central Rand Mines. We have several mines working on the Far East Rand; why do we not know what is the exact co-relation between percentage of minus 90 and grade in final pulp, and the actual extractions obtained? If statistics of the kind were prepared, we should find, although theoretically we should get a certain result, yet in actual practice so many things intervene that the theoretical result is partly obscured, and the final result may not be exactly what we are looking for. For example, last month we published in our *Journal* an analysis of ore on the East Rand; you find there nickel sulphide, pyrrhotite and arsenic sulphide; the more finely you grind these deleterious

— TABLES AND CHARTS. —

SERIES. A.

REF. 1

— CLEAN TAILING —

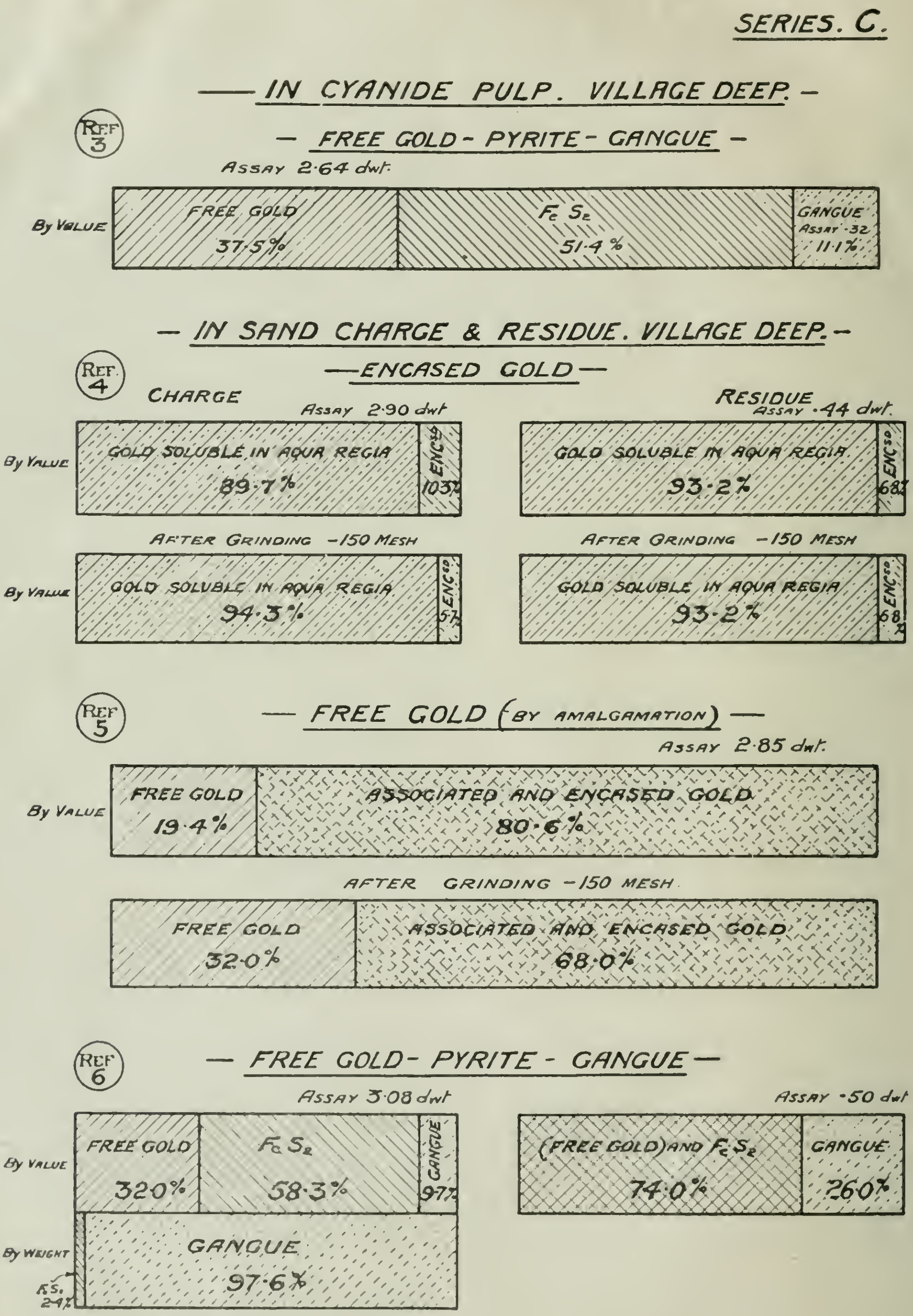
MATERIAL	CONSTRUCT.D ASSAY dwt.	% FeS_2 by SULPHUR DETERM.T	DISTRIBUTION OF GOLD.							
			CONCENTRATE CONSISTING OF PYRITE, FREE GOLD, AND FRACTIONAL GANGUE				CLEAN SILICIOUS AND ARGILLACEOUS GANGUE			
			% by WEIGHT	ASSAY dwt.	% VALUE	VALUE p.t. ORIGINAL	% by WEIGHT	ASSAY dwt.	% VALUE	VALUE p.t. ORIGINAL
SLIME CHARGE	1·56	1·99	4·51	22·0	63·5	0·99	95·49	0·60	36·5	0·57
SLIME RESIDUE	0·18	1·89	5·75	1·30	39·9	0·075	94·25	0·12	60·1	0·11
CYANIDE PULP	2·40	2·72	5·81	36·20	87·5	2·10	94·19	0·32	12·5	0·30

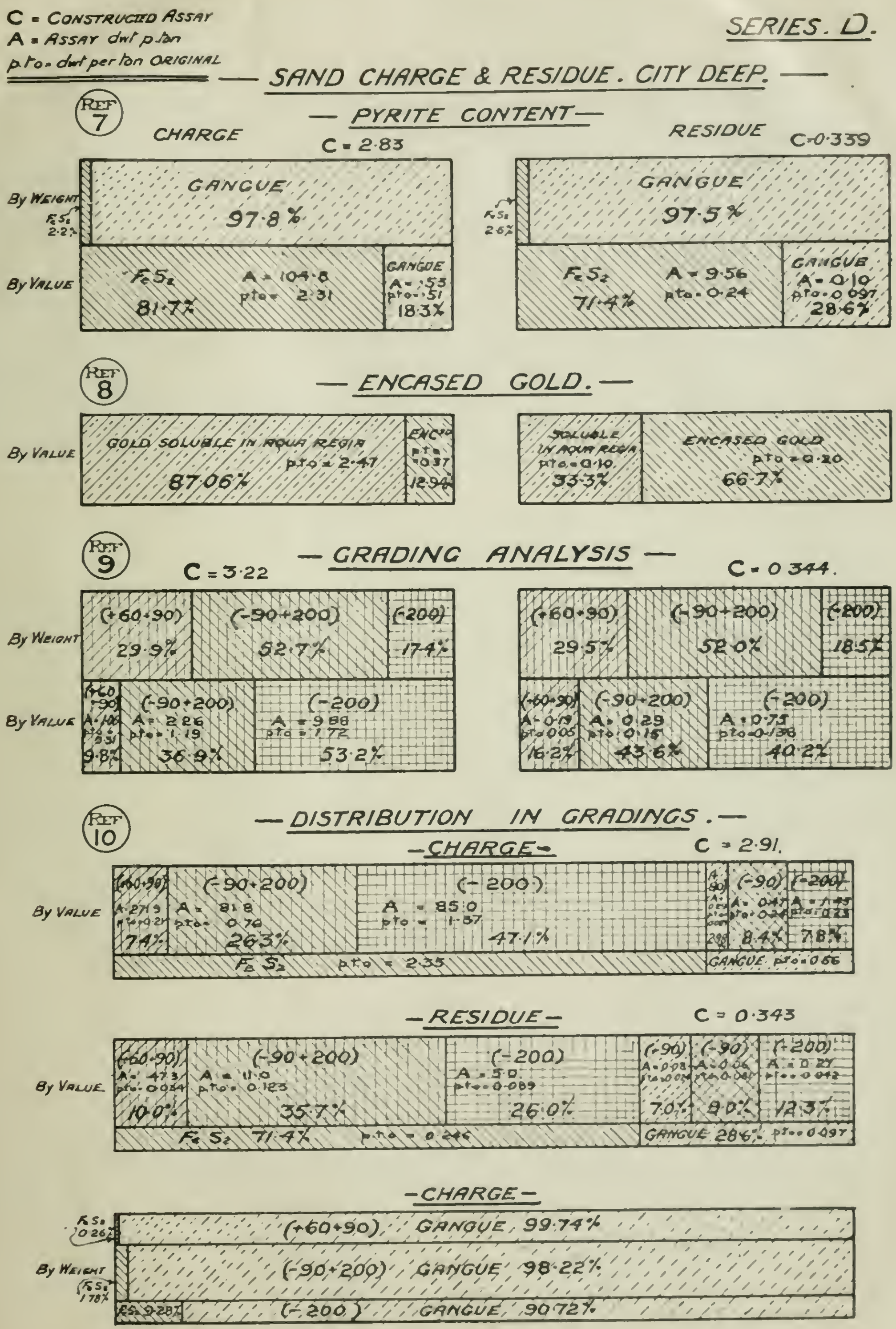
SERIES. B.

REF. 2

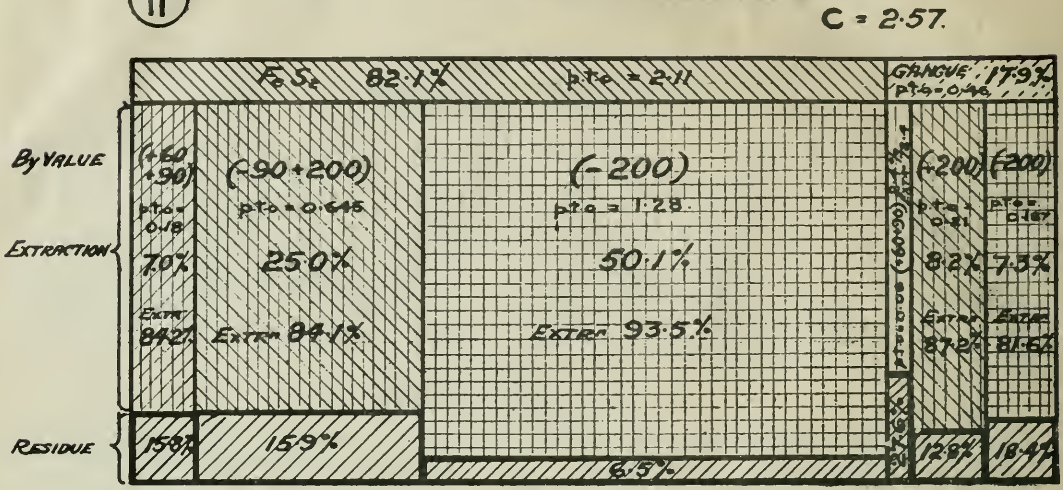
— CLEAN CONCENTRATE —

MATERIAL	CONSTRUCT.D ASSAY dwt	% FeS_2 by SULPHUR DETERM.T	DISTRIBUTION OF GOLD							
			CLEAN CONCENTRATE CONSISTING OF PYRITE AND FREE GOLD				SILICIOUS AND ARGILLACEOUS GANGUE WITH FRACTIONAL PYRITE			
			% by WEIGHT	ASSAY dwt.	% VALUE	VALUE p.t. ORIGINAL	% by WEIGHT	ASSAY dwt.	% VALUE	VALUE p.t. ORIGINAL
SLIME CHARGE	1·59	1·99	2·23	32·0	44·6	0·71	97·77	0·90	55·4	0·88
SLIME RESIDUE	0·176	1·89	2·18	1·2	17·1	0·026	97·82	0·13	82·9	0·15
CYANIDE PULP	2·21	2·72	3·11	55·1	77·3	1·71	96·89	0·52	22·7	0·50

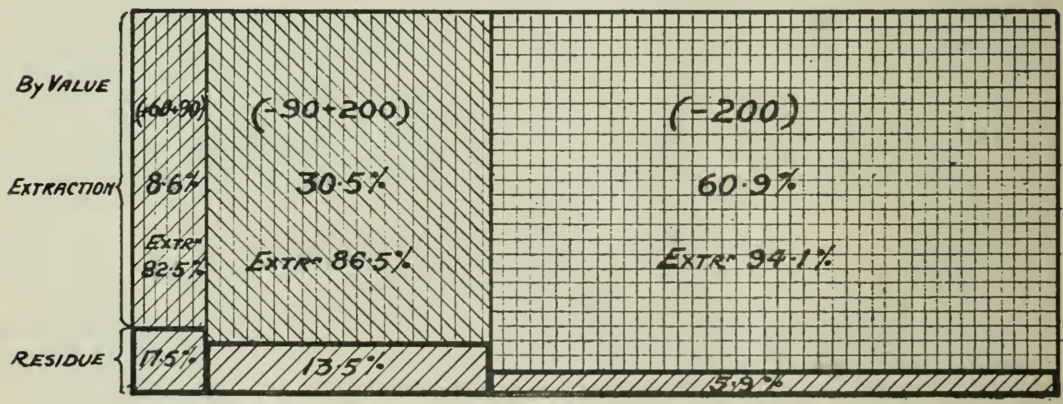

SERIES. C.
— IN CYANIDE PULP. VILLAGE DEEP. —
REF 3
— FREE GOLD - PYRITE - GANGUE —
ASSAY 2·64 dwt.
BY VALUE
FREE GOLD 37·5%
Fe S2 51·4%
GANGUE ASSAY ·32 11·1%
— IN SAND CHARGE & RESIDUE. VILLAGE DEEP. —
REF. 4
— ENCASED GOLD —
CHARGE
ASSAY 2·90 dwt
BY VALUE
GOLD SOLUBLE IN AQUA REGIA 89·7%
ENC'SD 10·3%
RESIDUE
ASSAY ·44 dwt.
GOLD SOLUBLE IN AQUA REGIA 93·2%
ENC'SD 6·8%
AFTER GRINDING -150 MESH
BY VALUE
GOLD SOLUBLE IN AQUA REGIA 94·3%
ENC'SD 5·7%
AFTER GRINDING -150 MESH
GOLD SOLUBLE IN AQUA REGIA 93·2%
ENC'SD 6·8%
REF 5
— FREE GOLD (BY AMALGAMATION) —
ASSAY 2·85 dwt.
BY VALUE
FREE GOLD 19·4%
ASSOCIATED AND ENCASED GOLD 80·6%
AFTER GRINDING -150 MESH
FREE GOLD 32·0%
ASSOCIATED AND ENCASED GOLD 68·0%
REF 6
— FREE GOLD - PYRITE - GANGUE —
ASSAY 3·08 dwt
BY VALUE
FREE GOLD 32·0%
Fe S2 58·3%
GANGUE 9·7%
BY WEIGHT
GANGUE 97·6%
F.S. 2·4%
ASSAY ·50 dwt
(FREE GOLD) AND Fe S2 74·0%
GANGUE 26·0%


C = Constructed Assay
A = Assay dwt p. ton
p.t.o. = dwt per ton original
SERIES. D.
— SAND CHARGE & RESIDUE. CITY DEEP. —
REF 7
— PYRITE CONTENT —
CHARGE
C = 2·83
RESIDUE
C = 0·339
By Weight
GANGUE 97·8%
FeS2 2·2%
GANGUE 97·5%
FeS2 2·5%
By Value
FeS2 A = 104·8 pto = 2·31 81·7%
GANGUE A = ·53 pto = ·51 18·3%
FeS2 A = 9·56 pto = 0·24 71·4%
GANGUE A = 0·10 pto = 0·097 28·6%
REF 8
— ENCASED GOLD. —
By Value
GOLD SOLUBLE IN AQUA REGIA pto = 2·47 87·06%
ENC pto = 0·37 12·94%
SOLUBLE IN AQUA REGIA pto = 0·10 33·3%
ENCASED GOLD pto = 0·20 66·7%
REF 9
— GRADING ANALYSIS —
C = 3·22
C = 0·344.
By Weight
(+60+90) 29·9%
(-90+200) 52·7%
(-200) 17·4%
(+60+90) 29·5%
(-90+200) 52·0%
(-200) 18·5%
By Value
(+60+90) A = 1·06 pto = ·31 9·8%
(-90+200) A = 2·26 pto = 1·19 36·9%
(-200) A = 9·88 pto = 1·72 53·2%
(+60+90) A = 0·19 pto = 0·05 16·2%
(-90+200) A = 0·29 pto = 0·15 43·6%
(-200) A = 0·75 pto = 0·138 40·2%
REF 10
— DISTRIBUTION IN GRADINGS. —
— CHARGE —
C = 2·91.
By Value
(+60+90) A = 27·9 pto = 0·21 7·4%
(-90+200) A = 81·8 pto = 0·76 26·3%
(-200) A = 85·0 pto = 1·57 47·1%
(-90) 8·4%
(-200) 7·8%
FeS2 pto = 2·35
GANGUE pto = 0·56
— RESIDUE —
C = 0·343
By Value
(+60+90) A = 4·73 pto = 0·034 10·0%
(-90+200) A = 11·0 pto = 0·123 35·7%
(-200) A = 5·0 pto = 0·089 26·0%
(-90) A = 0·08 7·0%
(-90) A = 0·06 8·0%
(-200) A = 0·27 pto = 0·042 12·3%
FeS2 71·4% pto = 0·246
GANGUE 28·6% pto = 0·097
— CHARGE —
By Weight
FeS2 0·26%
(+60+90) GANGUE 99·74%
(-90+200) GANGUE 98·22%
FeS2 1·78%
FeS2 9·28%
(-200) GANGUE 90·72%

REF 11 —DISTRIBUTION OF GOLD EXTRACTION—



REF 12 —EXTRACTION ON PYRITIC PORTION BY CYANIDE—



substances, the more likely are they to do injury to your solutions. That is one of the little things that may happen. The co-relation between finer grinding and increased extraction is not perfect, because while you are doing what is good, liberating the gold from the pyrite and the silicious matrix, at the same time you are doing something which is injurious, and in practice, therefore, you have to find a working balance. I make these statements as a plea that all records of this kind which are in existence should be examined from a statistical point of view, to find out what effect we are actually getting from putting into practice theories which we come down to this Society and so glibly announce. I have very much pleasure in seconding the vote of thanks to Mr. Wartenweiler for his very able paper.

SYMPOSIUM: MINERS' PHTHISIS.

Mr. Alex. Richardson: The formation of dust in drilling would be almost entirely prevented if a rotary type of drill could be substituted for the present noisy dust-creating types. Such a machine would certainly be preferable hygienically, and in all likelihood commercially to anything at present on the market; and it seems strange that its

Associated Scientific & Technical Societies of South Africa

CONDENSED PROCEEDINGS.

The 1st Annual General Meeting of the Associated Scientific and Technical Societies was held at 100, Fox Street, Johannesburg, on Wednesday, 16th February, 1921, at 7.30.

Dr. A. J. Orenstein (Vice-President) was in the chair, and 70 members were present.

The report and accounts for the period ending 31st December, 1920, were adopted.

Dr. A. J. Orenstein was unanimously elected President, and Messrs. J. W. Kirkland and D. M. Sinclair were unanimously elected Vice-Presidents for 1921/1922.

Mr. Reg. Saner was re-elected Hon. Legal Adviser for the year.

Messrs. Wilson & Tucker were elected Auditors for the year, their remuneration to be fixed at next Annual Meeting.

The question of establishing a bar was thoroughly threshed out, and it was finally agreed that the licence be applied for.

H.R.H. Prince Arthur of Connaught was elected Hon. Member during his period of office, and Sir Lionel Phillips, Sir Evelyn Wallers, and the Past-President, Mr. Percy Cazalet, were elected Life Members.

The proceedings terminated with a vote of thanks to the Chairman and Past-President.

Scientific and Technical Club.

100, FOX STREET, JOHANNESBURG.

The Club is now under the management of Mr. P. BOULTON, late of the Rand Club and the "Cecil."

A special feature is made of the catering service, especially morning and afternoon teas.

Hot and cold lunches will be served in the Dining Room from 12-45 to 2 p.m. at the following charges :—

HOT ...	Table d'Hote Lunch ...	2/6
COLD ...	,, ,, ,, ...	2/-
GRILLS ...	A la Carte	from 2/- to 2/6

Morning and afternoon teas will be served in the Lounge on the ground floor, where light lunches can also be obtained.

Tea or Coffee with Cut Cake, Scones, Biscuits or Brown and White Bread and Butter ...	6d.
With Fancy Cakes, Buttered Toast or Toasted Buns	9d.
Assorted Sandwiches with Tea or Coffee	1/6
Fruit Salad with Cream, Bread and Butter, Tea or Coffee	1/6

The Club will be open from 9 a.m. to 11 p.m. on weekdays, and from 12 noon to 9 p.m. on Sundays.

Dinners may be obtained by giving the Manager notice before 5 p.m. on the day before required. For the present, dinners will be served only to parties of not less than six, at charges which can be arranged with the Manager.

A Liquor Licence has been granted, and the Club Bar was opened on the 4th July.

Dances, etc., can be arranged for through the Manager for evenings when the Club is not used for Society Meetings.

Members of the Associated Societies are particularly requested to patronise the Club and the Restaurant, so as to ensure the success of the undertaking.

H. A. G. JEFFREYS,
Secretary.

discovery has been left in charge of the intermittent enthusiasms of inventors instead of having been encouraged by a well-sustained research. The difficulty of finding a boring bit capable of penetrating hard quartzite at a reasonable rate and cost has so far proved insuperable; but with the growing command over materials and their uses the problem is becoming less and less formidable.

Mr. Lionel Harris attributes the shortage of trained mining assistants on the Rand to miners' phthisis, the fear of contracting which is largely responsible for deterring young South Africans from adopting mining as a career, and is of the opinion that a somewhat analogous state of things exists in other countries. As far as Cornwall is concerned, the demand for mining school training is particularly strong, and the fear of possible injury to health through following the profession of a mining engineer does not seem to exercise any adverse influence. There would be no dearth of trained assistants on the Rand if the custom of other mining fields were followed. Among the fourteen countries to which Camborne students have gone in recent years, South Africa occupies only tenth place in order of attractiveness. The reason for this avoidance of a great mining field is that other countries guarantee a period of employment of from eighteen months to three years, and travelling expenses to the mine, while South Africa does not. One can hardly expect young fellows to spend £100, or so, in going out to look for problematical employment, with the off chance of being turned down by the Phthisis Board, and having to spend another £100 to get back. If South Africa is really anxious to obtain recruits for its mine staffs, a little imitation of the procedure followed in other countries will soon produce them.

THE IDEAL MINING LAW.

By C. J. Gray.

(Printed in Journal, September, 1920.)

REPLY TO DISCUSSION.

There is little to be said beyond thanking those who have joined in the discussion on my paper. In that paper I limited myself to consideration of principles, and those which I advocated appear to have been accepted as good. Mr. du Toit, however, differs slightly in one respect. He would give greater discretionary power to officials than seems to me desirable. In the prospecting and development stage he considers the most reasonable labour condition to be, that work be done to the satisfaction of some responsible official; he says that, while a mine is in a state of infancy, it is very necessary that the conditions of title be elastic, and that such elasticity is best exercised by granting the officer charged with supervision wide discretion. Section VII (c) of my paper, while recognising that some discretionary power must be given, states that the discretionary powers of officials should be very limited, and should in no case lessen security of title.

It is natural that an official with confidence in his own integrity, knowledge, and ability, should wish for a free hand so that he may do what appears to him best, and it is equally natural that the man whose individual interests or aspirations are checked by some hard and fast provision of a law should desire that the human element come into play; but there is another side to the question. Though an all-wise and benevolent autocrat is a desirable ruler, all autocrats are not benevolent, and no autocrat is all-wise. Mining officials are not without exception perfect in knowledge and virtue and, further, they often are not given credit for that knowledge and virtue which they really possess. If personal administration is to succeed it must be not only good, but generally accepted as good.

To my mind it is, on the whole, better to waive much of the advantage obtainable from discretionary powers in order to obtain the certainty and security given by a definite law. The law should be carefully framed so as to ride very lightly on prospecting and development, but it should be as definite as possible.

CEMENTATION OF THE SUBSTRATA OF THE MAZOE DAM RETAINING WALL.

By Dr. G. A. Voskule.

(Printed in Journal, November, 1920.)

REPLY TO DISCUSSION.

At a meeting of your Society, held on the 16th April, 1921, Mr. Weston raised the question of mixing sand with the cement for injection into the rock of the Mazoe Dam foundations, thereby saving a considerable amount of cement. I might point

out that the figure £10,000 was the total cost, including purchase of plant, diamonds, etc. However, the principle remains the same whatever the cost.

Mr. Toombs replied, giving the reason why a mixture was not used, which, in fact, is what happened when we tried to use a mixture in this case. When we have a case where the spaces are larger and the mixture travels directly into them without having to pass along fine or small fissures to reach the larger ones we do use mixtures with advantage.

I hope your Society will grant me the opportunity at some future meeting of laying before you a description of some very interesting, and hitherto unattempted work, which we recently carried out successfully on the Reef, using for injection mixtures of slime and cement.

CHEMICAL METHODS OF DE-AERATION OF WATER SOLUTIONS.

By H. A. White.

Mr. H. A. White: As there was so little discussion on my paper, it does not call for any extended reply on my part. I only wish to thank Mr. Stevens and Mr. Wartenweiler for their contributions, and to take this opportunity of informing the Society that a Sub-Committee of the Council of the Society has been formed which will receive any suggestions for researches, any application for funds in connection with researches—a Sub-Committee of which I happen to have the honour to be a member. I thought this would be a suitable opportunity to mention this matter because no doubt there are several difficulties with which men working on the mines are familiar, and on which they would like to have further light, and on which it would be of importance to the industry and the country they should have further light.

Mr. F. Wartenweiler: I would like to move a vote of thanks to our retiring President, who is unavoidably absent. Mr. Chilton devoted a great deal of his time to the interests of the Society; he was very keen in what he did, and was very loath to leave before his term of office expired. I move a vote of thanks to Mr. Chilton.

The Chairman: Our next meeting will be on the 17th September next; there will be two months' recess. The *Journal* will be published as usual. I believe we have a paper for next month, and I hope something will be forthcoming for August and future months.

The meeting then terminated.

THE SOCIETY'S ROLL OF HONOUR.

THE GREAT WAR, 1914-1919

The following is the List of Members and Associates who have served:—

KILLED OR DIED ON ACTIVE SERVICE.

Lieut. M. S. E. Archibald, Royal Engineers.
Lieut. C. Y. Bruce, Royal Engineers. (Killed in action, France, 28th March, 1918.)
Lieut. T. H. Clesham, Royal Engineers.
Lieut. W. J. N. Dunnachie, a Tunnelling Company of the Royal Engineers. (Killed in action in France, 24th April, 1916.)
Lieut. A. R. Flynn, Natal Carbineers.
Lieut. William Godfrey Froude, D.C.M., Imperial Light Horse. (Killed in action during Rebellion in the Western Transvaal, 25th Nov., 1914.)
Lieut. Frederick Niven Gerds, 176th Tunnelling Company, Royal Engineers. (Died from gas poisoning, France, 2nd June, 1915.)
Capt. J. V. Harris, M.C., Cape Corps. (Killed in Palestine).
Capt. C. K. Digby Jones. (Died of pneumonia in Russia).
Lieut. B. A. Johnson, formerly Private, 5th Batt., The Buffs.
Lieut. A. D. Johnson, 2nd South Staffs. (Killed in action,, 25th September, 1915).
Lieut. William Nicklin, 2nd Batt, Special Brigade, Royal Engineers. (Killed in action, August 24th, 1916.
Major W. H. Pickburn, South African Heavy Artillery.
Sergt. William Harry Poynton, 27th Batt., Australian Imperial Forces. February, 1915.
Capt. R. W. Robinson, 5th Royal Irish Fusiliers. (Killed in action, Dardanelles, 15th August, 1915)
Lieut. G. Simpson, Jr., 18th Durham Light Infantry. (Killed in action, Flanders, 4th July, 1915).
D. W. Stacey. (Died in France, 1917).
Lieut.-Col. F. J. Trump, D.S.O., Croix-de-Guerre. Capt.. 1st Monmouth Regt.; Lieut.-Col., South Staffs.

ON ACTIVE SERVICE.

Adler, H. W., 2nd-Lieut., Royal Engineers.
Allen, D. L., Rand Rifles.
Anderson, W., Oct., 9th S.A. Infantry.
Andrews, Alan A., Nov., 2nd S. A. Horse.
Arkeil, D. J., Gunner, 73rd Siege Battery, S.A. Heavy Artillery.
Aymard, M., Lieut., Royal Air Force.
Atkinson, F. R., 3rd S.A. Infantry.
Balfe, M. F., 3rd S.A. Infantry.
Ball, H. Standish, Major, Asst. Inspector of Mines, G H.Q. (France). Three times mentioned in despatches. Awarded O.B.E.
Barratt, R. L., Lieut., 1st S.A. Horse.
Baskett, E. G., Lieut., Nigerian Regt., West African Frontier Force.
Baumann, Max, Naude's Scouts.
Beardwood, J. P., Mechanical Transport.
Bell, D. B., Lieut., Royal Air Force.
Bluett, H. A. N., 2nd-Lieut., 182nd Tunnelling Co., Royal Engineers.
Bolitho, E. J., S A. Medical Corps.
Boyd, J. A., S.A. Motor Despatch Riders Co. Awarded D.C.M.
Burt, W., Maxim Gun Section, Union of S.A. Forces.
Bulman, G., Lieut., S.A. Service Corps, Motor Transport.
Caddy, J. P., Australian Expeditionary Force.
Cockburn, P. A., Lieut., Royal Engineers.
Collins, W. L., Imperial Light Horse.
Cowles, E. P., Jan., Capt., 170th and 176th Tunnelling Co.'s, Royal Engineers.
Croghan, E. H., Lieut., 381st Battery, Royal Field Artillery, 158th Brigade. Mentioned in despatches.
Dakin, N. W., 10th S A. Infantry.
Dealey, J. G., Lieut., 12th S.A. Infantry
Dennison, J. A. 2nd-Lieut., Royal Garrison Artillery.
Dick-Cleland, A. F., Capt, Royal Engineers.
Dixon, Clement, Rhodesian Reserve Force.
Dixon, J. M., 1st S.A. Horse.
Donkin, H. F.
Donkin, W., Sergt., 2nd Rhodesian Regt.
Drought, J. J., Major, Actg. Provost-Marshal and Camp Commandant, G.H.Q. Twice mentioned in despatches: awarded Military Cross; Chevalier de l'Ordre de Leopold II.
Filley, O. D., Lieut., Royal Engineers. Awarded Military Cross.
Fox, G. C., Major, Transvaal Scottish.
Geddes, J. G., Capt., 176th Tunnelling Co., Royal Engineers.
Gibb, J. A. P., Lieut., Royal Engineers.
Gilbert, T. W., Lieut., Royal Garrison Artillery.
Gilchrist, D., Capt., 258th Co., Royal Engineers
Gill, H. W., Sergt., S.A. Medical Corps (Sanitation).
Gow, G. A., Engineering Branch, New Zealand Expeditionary Force.
Graham, W. H., Jan., Rhodesian Platoon, 3rd Batt., King's Royal Rifles, 80th Brigade, 27th Division (France).
Gross, L. A., Rand Rifles.
Halford, E., Jan., Trench Mortar Battery, 12th Division.
Harrison, M. J., Imperial Light Horse.
Heatley, W. B., Q.M.-Sergt., 7th S.A. Infantry
Irvine, Dr. L. G., Capt., S.A. Medical Corps.
Jeffreys, H. A. G., Capt., East Africa Pay Corps. Awarded O.B.E.; Chevalier de l'Ordre de la Couronne (Belge); mentioned in despatches.
John, W. E., Lieut., S.A. Aviation Corps.
Johnson, Dr. J. Pratt, Major, S.A. Medical Corps.
Lakeland, W. J., Lieut., Indian Army Reserve of Officers.
Lathbury, F. H., Capt., Royal Engineers.
Leyson, L. T., S.A. Medical Corps.
Lloyd, J. J., Tpr., East African Mounted Rifles.
Locke, A. N., Mechanical Transport.
Lockhart, T. L.
Mance, J. C., Capt., Deputy Asst. Director of Railway Transportation (France).
Mares, W. H., Imperial Light Horse.
Marks, L., 2nd-Lieut., Special Brigade, Royal Engineers.
McAlpine, H., S.A. Heavy Artillery.
McPadden, J. F., Capt., New Zealand Expeditionary Force.
Nettleton, S., Lieut., Royal Engineers.
New, W. S., 2nd-Lieut., Royal Engineers.
Newbery, J. W., Major, British Military Mission to Siberia. Awarded Military Cross.
Nicholaus, R. C., Major.
Nissen, P. N., Lieut.-Col., Royal Engineers. Awarded D.S O.
Ordman, D., Mechanical Transport (East Africa).
Orenstein, Dr. A. J., Col., Actg. Director of Medical Services, South Africa. Awarded C.M.G.
Pam, Edgar, Lieut.-Col., Royal Engineers, attached to G.H.Q., Army of the Rhine. Awarded O.B.E.
Paterson, G. S, Capt., Royal Garrison Artillery; subsequently transferred to Royal Air Force.
Patterson, P. F., Capt. and Adjutant, 7th Batt., York and Lancaster Regt. Mentioned in despatches.
Pearce, J. W., Lieut., Natal Light Horse.
Phillips, F. D., Capt., 8th Royal Berkshire Regt. Awarded Military Cross.
Pitt, C. K., Capt., Tunnelling Co., Royal Engineers. Awarded Military Cross.
Porter, R. A., 2nd Transvaal Scottish.
Pryce, L., 2nd-Lieut. and Observer, Naval Kite Balloon Section, Royal Air Force.
Pryor, Thos., Capt., Indian Army Reserve of Officers. Awarded D.S.O.
Price, W. S. V., Miscellaneous Trades Co.
Rabone, P., Lieut., Royal Engineers.
Railton, R., Royal Air Force.
Reed, Wm., Lieut., Special Brigade, Royal Engineers. Awarded Military Cross.
Reynolds, A. E., Royal Flying Corps (East Africa)
Richardson, W. P., Botha's Light Horse.
Ruggles-Brise, H. R., Capt., General Staff Officer, 3rd grade, attached to G.H.Q. (France) Awarded Military Cross; Croix-de-Guerre (Belge).
Robertson, J. R. H., Lieut., Kolar Gold Fields Volunteers.
Sale, G. G., Capt., Royal Engineers. Awarded D.S O. and M.C.
Sim, A. Malcolm, Lieut., Royal Engineers.
Simpson, F. L., Lieut., Essex Yeomanry.
Smith, G. Hildick, Lieut., 1st Transvaal Scottish (S.W. Africa); subsequently Head of the Technical Section, Food Production Dept. (Board of Agriculture), London.
Solomon, L., Capt., 177th Co., Royal Engineers.

Spence, A. G. B., 9th S.A. Infantry.
Stephens, A. H., Rand Rifles.
Stidolph, N. H., S.A. Heavy Artillery.
Stokes, R. S. G., Lieut.-Col., Controller of Mines. First Army (France); 1919, with North Russia Expeditionary Force as Col., C.R.E. Awarded D.S.O., O.B.E., and M.C.
Swinney, L. A. E., Major, Royal Engineers.
Swinburne, U. P., Lieut.-Col., Seaforth Highlanders.
Thomas, H., Aug., 1914, Motor Transport Corps (East Africa).
Thomas. Wm., Lieut., Kolar Gold Gields Volunteers.
Thomas, H. T., Lieut., Kolar Gold Fields Volunteers.
Thorpe, W. E., Pte., S.A. Medical Corps.
Tredgold, R. H., Lieut., King's African Rifles.
Trevor, T. G., Major, Union Forces.
Villiers, J. de, 3rd S.A. Infantry.
Waterson, H., Witwatersrand Rifles.
Weeks, R. F. J., Capt., 171st Co., Royal Engineers.
Weinbren, M., S.A., Motor Cycling Corps.
White, J. L., Witwatersrand Rifles.
Williams, G. W., Major, Royal Engineers. Awarded D.S.O. and M.C. Twice mentioned in despatches.
Winters, R., Heavy Artillery Brigade.
Wood, A. A., Lieut., 9th S.A. Infantry.
Wood, S., Botha's Light Horse.
Wraith, C. O., Lieut., 182nd Co., Royal Engineers. Mentioned in despatches.
Wright, L. A., East Africa.
Williamson, H. B., Lieut., 6th Worcester Regt. Awarded Military Cross.

On service with Ministry of Munitions, etc.:—
Adams, A. E.
Alston, R. A.
Cameron, W. McC.
Cullen, William.
Milliken, A.
Quinan, K. B. Awarded Companion of Honour.
Richardson, A.

Notices and Abstracts of Articles and Papers.

CHEMISTRY

Molybdite.—" Molybdite ($Fe_2O_3,3MoO_3,7\frac{1}{2}H_2O$), which commonly accompanies molybdenite, is not amenable to concentration by flotation; hence serious losses of molybdenum may occur when using this method of concentration with ores containing molybdite. The presence of this mineral may be detected by leaching the ore with a boiling 10% solution of ammonia, sodium carbonate, or hydrochloric acid. The solution is filtered, after having been made ammoniacal if acid was used, the filtrate acidified with hydrochloric acid, and thiocyanate added, followed by zinc. A bright cherry-red colour, which is extracted when shaken with ether, shows the presence of molybdite. To determine the molybdenum present in the oxidised form 5—10 g. of finely ground ore is extracted as above, the solution, if alkaline, acidified with hydrochloric acid, treated with a little hydrogen peroxide, then with an excess of ammonia, boiled and filtered. The filtrate is acidified with hydrochloric acid, 5—10 g. of ammonium acetate added, and the liquid titrated with a standard solution of lead acetate. A slight excess of the acetate is eventually added and the precipitate filtered off, ignited, and weighed as lead molybdate."—J. P. Bonardi, *Chem. and Met. Eng.*, 1920, *23*, 205—206. —*Journ. Soc. Chem. Ind.*, Sept. 30, p. 630A. (A. W.)

Separation of Magnesium from Sodium and Potassium Chlorides.—" The chlorides of magnesium, sodium, and potassium are dissolved in the minimum quantity of water (about 1·5 cc. for 0·5 g.) in a 100—150 cc. beaker flask, 1 drop of concentrated hydrochloric acid is added, and gradually 25 cc. of absolute alcohol is dropped into the middle of the beaker while rotating; the sodium and potassium chlorides should precipitate in a uniform granular condition. In a similar manner, while rotating the beaker 25 cc. of ether (U.S.P.) is added. When the precipitate has agglomerated and the supernatant liquid is nearly clear, the mixture is filtered through a weighed Gooch crucible into a 150 cc. conical flask, using only mild suction to avoid drying the precipitate too soon. The beaker is washed with a mixture of 1 pt. of alcohol and 4 pts. of ether and the washings passed through the filter. The filtrate is evaporated to dryness and the residue treated with 10 cc. of alcohol. One drop of concentrated hydrochloric acid is added and the mixture warmed until practically all has dissolved. The beaker is then rotated, 50 cc. of ether slowly added, and the mixture kept for 20 min. The precipitate is collected in the same Gooch crucible, washed as before, then dried, ignited, and weighed. The filtrate is evaporated to dryness, the residue treated with 5—10 cc. of hydrochloric acid and a little water, and the magnesium estimated in the usual manner."—S. Palkin, *J. Amer. Chem. Soc.*, 1920, *42*, 1618—1621.—*Journ. Soc. Chem. Ind.*, Sept. 30, p. 642A. (A. W.)

Magnesia Mixture.—" Magnesia mixture for the precipitation of phosphoric acid if prepared without the addition of ammonia may be kept indefinitely in glass bottles without the glass being attacked. The requisite quantity of ammonia is added after the phosphate solution has been treated with a slight excess of the reagent."—O. Kuhnt, *Chem.-Zeit.*, 1920, *44*, 586.—*Journ. Soc. Chem. Ind.*, Sept. 30, p. 641A. (A. W.)

METALLURGY.

Comparison of Ten Different Methods of Estimation of Calcium.—" Calcium was estimated by the following methods in a specimen of calcite containing 0·0407% of impurities (silica, iron and alumina), the results being expressed as percentages of $CaCO_3$:—(1) Precipitation as oxalate and weighing as carbonate, 99·57%. (2) Precipitation as carbonate and weighing as such, 100·07%. (3) Weighing carbon dioxide liberated by hydrochloric acid by absorption in potassium hydroxide solution, 100·03%. (4) Precipitation as oxalate and weighing as oxide, 99·86%. (5) Precipitation as sulphate and weighing as such, 99·68%. (6) Precipitation as oxalate and weighing as sulphate, 100·39%. (7) Precipitation as oxalate and titration with permanganate, 99·68%. (8) Precipitation as oxalate from a slightly acid solution, 99·87%. (9) Weighing by difference carbon dioxide liberated by hydrochloric acid in a Geissler apparatus, 99·80%. (10) Decomposition by excess of standard sulphuric acid and

back titration of the excess, 99·75 %."—G. E. Ewe, *Amer. J. Pharm.*, 1920, *92*, 401–410.—*Journ. Soc. Chem. Ind.*, Aug. 31, 1920, p. 585A. (J. A. W.)

OXYGEN IN CYANIDE SOLUTIONS.—"White's method for the estimation of oxygen in cyanide solutions (*J.*, 1918, 517A) depends on the degree of coloration imparted to a cyanide solution by the addition of either methyl orange, acid, and potassium chromate, or a solution of pyrogallol and caustic soda oxidised to saturation and then diluted to the shade required. By the first of these methods it is difficult to obtain a match, while in the second the colour produced fades in daylight, thus preventing its use as a standard for more than a brief period. A perfect colour match is obtained by the use of a solution of caramel; the tint appears to be permanent as far as could be observed in a period of three to four weeks, a slight fungoid growth produced after ten or twelve days being prevented by the addition of formaldehyde. Determinations by this modified method can be made to 1 mg. of oxygen per litre."—E. M. HAMILTON, *Eng. and Min. J.*, 1920, *110*, 116.—*Journ. Soc. Chem. Ind.*, Aug. 31, 1920, p. 571A. (J. A. W.)

MISCELLANEOUS

GENETIC PROBLEMS AFFECTING SEARCH FOR NEW OIL REGIONS.—Most oil and gas geologists agree that in those formations in which oil is found there must be sufficient organic matter genetically to account as mother substance for the oil, which is believed to have escaped from its mother rock into some suitable and accessible reservoir rock where it is confined beneath impervious strata. "Bituminous" or other carbonaceous shales and limestones are almost invariably searched for because, seemingly with good reason, such deposits are regarded as the principal materials from which petroleum may be generated. Circumstantial evidence—the conditions actually presented in certain oil fields—seems to indicate that the carbonaceous matter need compose but a very small percentage of a supposed mother formation, and that a very great thickness of the mother formation is not indispensable. In general, however, our most productive oil deposits are found in districts containing formations in which there is evidence of abundant life, with ample vegetal matter.

The term "organic matter" should be restricted to carbonaceous debris and residues, as distinguished from non-carbonaceous mineral deposits of organic origin, such as shells, diatoms, etc., which may now be devoid of any associated hydrocarbons. Such mineral deposits do not serve as mother substance of oil, although, when porous, they may offer excellent storage.

No commercially important oil fields have yet been discovered in any area where the fuel ratios of the coals, occurring in the formations in which oil is sought or in overlying formations, exceeds 2·3. The progressive devolatilization by which the coals in any region or formation have been transformed from peats to lignites, bituminous coals, etc., and finally to graphite, is the first indication of incipient metamorphism of the rocks of the area.

More observations and tests are necessary to fix more exactly the stage of regional alteration beyond which commercial oil pools, though formerly present, will not have survived, but it is probable that the limit falls, in general, slightly lower than the point at which coals of the ordinary bituminous type show a fuel ratio of 2·2, or 68 per cent. of fixed carbon in the pure coal; it may approach nearer the ratio of 2·0, or 66 per cent. fixed carbon. Coals verging toward the sapropolic type, such as are believed by many to approach more closely the typical mother substance of oil, are more fatty and accordingly richer in hydrogen and lower in fixed carbon (pure coal basis) than the other types, until, in the course of alteration by geologic processes, they approach the above limit, when the volatile matter seems to disappear rapidly. At the semi-bituminous stage (fuel ratio 3·0, fixed carbon 75 per cent.), their carbonization is approximately on a parity with typical bituminous coal.

It is important that, in a new region under consideration as to oil possibilities, every precaution be taken to ascertain whether the alteration of the rocks, as indicated by the stage of carbonization of the carbonaceous deposits, has not gone so far as to preclude the survival of oil in commercial amounts. Drilling in regions of greater metamorphism will find only gas or mere showings of "white oil"—approximately kerosene—generally little more than samples, and nowhere in commercial amount.

It should be noted that: (*a*) local, slight variations of carbonization are not to be ignored, for they are to be expected, especially in closely folded and faulted areas; (*b*) in general, carbonization advances downward, according to the law of Hilt, so that the fuel ratios of coals in underlying formations will, in most cases, be higher than in the exposed formations, thus offering no hope of getting oil at greater depths where the regional alteration of the exposed rocks is too great; (*c*) the carbonization rule applies only to areas in which the alteration is regional, not contact metamorphism; (*d*) the fuel ratios are typically based on coals or coaly deposits of the so-called bituminous group, and may be satisfactorily determined in coaly streaks, in very earthy and bony coals, and in shales containing great amounts of organic matter, though it is not yet proved that they can be determined in shales carrying but small percentages of carbonaceous matter. Attempts to determine the percentage of fixed carbon in the organic matter of ordinary carbonaceous shales have not yet been wholly successful.

As bearing upon the grade of oil that may be expected in a new region, attention may again be called to the observation that, in general, the oils in regions of relatively high, but not too high, carbonization are characteristically of the highest grade, that is, of low gravity; while in regions of less carbonization the oils average higher in gravity. Going still further, the oils found in regions of low-rank coals, such as lignites (brown coals), are also characteristically, though not without exception, lowest in rank.

Folding of the strata, or the development of structure, is almost universally regarded as an essential feature of an oil region.

However, to what extent and through what processes folding operates as a cause, or a means, or, on the other hand, whether it is to be regarded only as an effect or a mere indication, is yet to be shown.

In previous discussions of the features common to the genesis of coal and of oil, the writer has insistently pointed out that the evolution of each is brought about through common agency of dynamic forces—mainly horizontal stresses—acting on loaded strata and causing the progressive devolatilization of the organic debris and residual products buried in the sedimentary deposits. Both coal and oil are products of alteration, by geologic processes, of organic matter not only similar, but, at least, in part, identical in composition. Coal consists of the mass or stratum of relatively pure organic debris, including the residual solid hydrocarbons left in the process of transformation from peat, or its genetic equivalent (deposited under different conditions), to graphite. Oil, on the other hand, is a volatile product of this natural "distillation" by the same agencies, of the organic debris and residues buried in the sedimentary deposits.

Experimental evidence strongly, but not conclusively supporting the pressure theory of the origin of oil has recently been adduced by Alex. W. McCoy, geologist of the Empire Gas and Fuel Co. By means of pressure on the ends of a cylinder of oil shale enclosed in a tube, the walls of which were thinner in the central zone than at the ends, so as to allow bulging, Mr. McCoy was able to induce flowage in the oil shale, and, without causing an appreciable amount of heat, developed small globules of oil in the shale which were visible with a hand lens. The material used in the experiment was typical oil shale, capable of yielding 25 gal. (94·61) of oil to the ton, and having a crushing strength of about 3,000lb. per sq. in. (211 kg. per sq. cm.). No oil could be removed by solvents prior to the experiment.

It appears probable that, in regions where the thrusts have been sufficient to cause well loaded strata to form anticlines, the stresses have been great enough to cause the generation of petroleum. Contrary to the views of most geologists and chemists, it would appear that the heavy oils, buckling or undulation under favourable conditions, are the first products of oil generation, while the light oils, occurring in the regions of greater thrust, are the more refined products.

On the other hand, it would appear probable that, in general, oil either is not present or is not segregated in series of sedimentary formations that have been thrust sufficiently to cause some bucking or undulation under favourable conditions, with the requisite amount of loading. If not sufficiently loaded, they are likely to remain unconsolidated though they may have been folded.

In the genesis of an oil pool not only is the organic debris altered and devolatilized, with the generation of petroleum and natural gases, as the result of dynamic thrust stresses attending diastrophic movements, but the migration and segregation of these hydrocarbons, disseminated in their place of origin in the mother rock, are promoted, if not caused, by the molecular rearrangement and the movement of rock grains consequent to these stresses. Most, by far, of the oil and gas is generated under the influence of differential stresses in "impervious" beds, the larger part being formed in the midst of typically impervious deposits, mainly organic muds, carbonaceous clays, fine-grained shales, and dense organic strata, such as oil shales, than which few unaltered sediments can be more impervious. The molecular displacement and the readjustments of the particles of the rock are essential to the migration of the newly formed oil and gas, and of the water, in the directions of least resistance, which, other things being equal, will be toward those beds, or regions of beds, most resistant to pressure and within the pore spaces of which the pressure will be relatively less.

It would appear, that during a period of diastrophic stresses, the conditions have repeatedly been favourable for the evolution of the oil, the displacement and rearrangement of the organic particles and rock grains, the coincident rupture, enlargement, decrease or rearrangement of the pore spaces and capillaries, the development of zones of varying pressure, the overcoming of friction, and the disorganization of capillary resistance. In short, the conditions must have been most favourable (*a*) for squeezing oil, gas, and water out of their impervious source, through the intervening, impermeable, organic and argillaceous deposits, into the less compressed regions of the sandy rocks, sandstones, and porous limestones; (*b*) for their migration in spite of capillary resistance; and (*c*) for their eventual escape into the most porous, coarse-grained reservoir available, where, under a relative stability of the rock material, segregation and gravitation may be assumed to have taken place, subject to the effect of capillary tension. —David White, U.S. Geological Survey, *Mining and Metallurgy*, February, 1920, No. 158, Section 21. (C. J. G.)

Deep Level Ventilation—Effects of Atmospheric Pressure.—"If divers went to one atmosphere extra no palsy occurred. They had to go to two or three atmospheres and be a considerable time exposed to it, and then they got the nitrogen bubbling off. Coming up rapidly from 7,000 ft. there was no danger whatever of nitrogen bubbles coming off.

"The excessive spitting of miners coming up to the surface which Mr. Holman had referred to—which he (Mr. Holman) had suggested was due to nitrogen bubbles being released from the lung tissues—was new to him, but he should have thought it was very largely associated with the great change of humidity and temperature which the men were subjected to in coming up from the deep workings where the air perhaps was at 85° F. saturated, to the top where it was perhaps at 60° and only half saturated. That meant a tremendous change on the mucous membrane, which had to warm up to almost body temperature and saturate at that temperature all the air breathed. Enough blood had to flow through the membrane to warm the air and enough secretion produced to saturate it, and the sudden and unnatural strain on the membrane when people came from hot rooms to cold air out of doors was, he believed, one of the causes of the colds frequently contracted. People who lived out of doors were exceptionally free from colds."—Dr. Leonard Hill, *Bull. Inst. M. and M.*, April, 1921, p. 10. (H. A. I.)

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(COMPILED BY THE SECRETARY, H. A. G. JEFFREYS, O.B.E.)

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